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ANGIOGRAPHY IN RENAL TRAUMA

by

OLLE OLSSON and ANDERS LUNDERQUIST

Renal rupture represents a fairly high percentage of abdominal injuries. WILLIAMS & ZOLLINGER (1959) in a survey of 273 abdominal injuries in the period 1947—1958 found that 76 were in the urinary tract and that the kidney was involved in 58. Of 62 cases of renal injury seen at our department, 27 were caused by traffic accidents (NILSSON & SANDBERG 1962).

Examination by conventional roentgenography followed by urography are usually considered the methods of choice in the examination of cases of probable renal rupture. The predominant roentgenologic signs suggesting renal rupture are the loss of part or whole of the outline of the kidney, the failure to identify the lateral border of the psoas muscles, and the presence of a soft tissue mass. Urography may demonstrate a deformed renal pelvis due to its rupture or compression by an intrarenal haematoma, and compression of the kidney or pelvis by an extrarenal haematoma. Deformation may also be caused by a blood clot or by two or more of these factors in combination. The demonstration of extravasation of contrast medium from the renal pelvis into the parenchyma or outside the kidney provides a conclusive sign of rupture. Such unequivocal evidence is seldom obtainable because the methods usually necessary to demonstrate these changes cannot be used. Pyelography is contraindicated, and the application of ureteric compression in association with

From the Roentgendiagnostic Department (Director: Prof. Olle Olsson), University Hospital, Lund, Sweden. Submitted for publication 27 March 1962.

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Group I Acute stage of renal injury

Case 1 Girl aged 12 years with haematuria following blow on the right side of the lower thorax

Roentgen examination Increased density of right upper quadrant with complete loss of the retroperitoneal markings including the outline of the right kidney

Urography Normal conditions on the left side The excretion on the right side was delayed and poor and the filling of the renal pelvis was incomplete (Fig 1a)

The patient was re examined 12 days later because of persistent haematuria *Roentgen examination* No change since previously *Urography* Good excretion on right side The lateral ventral part of the renal pelvis was markedly compressed (Fig 1b)

Right selective renal angiography 3 days later 15 days after accident (the haematuria had subsided during the last 2 days) The intrarenal branches were slightly displaced dorsally A rupture extended through the entire parenchyma into the sinus somewhat cranially to the middle of the kidney the defect was widest ventrally more narrow dorsally and continued caudally The rupture was best seen in the right oblique view (Fig 2 a and b) No changes in the outline of the kidney could be seen in a p projections The intrarenal arteries were slightly displaced (Fig 2c)

Case 2 Man aged 18 with haematuria after an elbow had been thrust into his left flank Slight temperature fairly good general condition

Roentgen examination The left kidney could not be outlined *Urography* Excretion on the right side was normal but the density on the left side was decreased The lower part of the renal pelvis was only partly filled The confluence of the renal pelvis was displaced slightly upwards (Fig 3a)

Left selective renal angiography 5 days after accident The main renal artery and the lower intra renal arteries (both ventral and dorsal branches) were displaced slightly outwards and upwards The medial capsular artery was arched medially (Fig 3 b and c) The size and shape of the kidney was normal The upper pole was displaced laterally by a medial and extra renal soft tissue mass No signs of renal rupture

Conclusion Extrarenal haematoma

Case 3 Man aged 56 had fallen against a wedge haematuria poor general condition

Roentgen examination 3 hours after accident The right kidney could not be outlined A homogeneous mass was present in the retroperitoneal space on the right side

Urography The right kidney was markedly displaced caudally the density of the excretion was somewhat low and the filling of the renal pelvis was incomplete (Fig 4a)

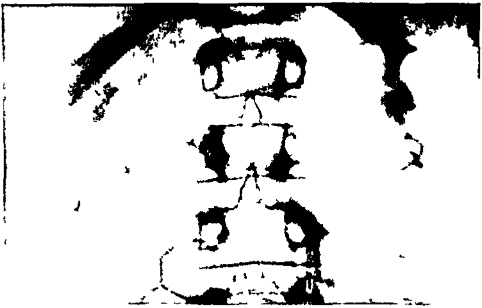
Aortic renal angiography 2 days after accident The right renal artery was stretched and displaced caudally (Fig 4 b and c) The superior capsular artery was arched widely upwards from the kidney surface The right kidney was depressed and rotated with the upper pole displaced laterally No signs of renal rupture

Conclusion Large extrarenal haematoma

Case 4 Man aged 19 with haematuria following traffic accident good general condition

Roentgen examination The kidneys and the psoas muscles could not be outlined completely On re examination 3 days later only the medial contour of the lower pole of the right kidney could be defined A small soft tissue mass around the lower pole depressed the hepatic flexure (Fig 5a)

Urography No abnormality on the left side Excretion on the right side was not delayed The filling of the lower part of the confluence of the renal pelvis and inferior calyces was incomplete and compression of the upper ureter was noted



a



b

Fig 1 Case 1 a) Urography Good excretion on left side impaired excretion on right side with incomplete filling of pelvis b) Urography repeated 12 days later because of persistent haematuria Excretion on right side improved marked medial displacement of right renal pelvis and impression of its lateral outline (Cf fig 2)



a b c

Fig 2 Case 1 (see also fig 1) Right selective renal angiography 15 days after trauma. Haematuria had subsided during the last two days a) Oblique view arterial phase b) Nephrographic phase Rupture in anterior and posterior part of renal parenchyma into sinus where rupture continues caudally displacement of intrarenal arterial branches by haematoma ventrally in sinus c) Frontal projection arterial phase Only displacement of intrarenal arterial branches evident This case illustrates necessity of suitable projections to demonstrate rupture

Selective right renal angiography 3 days after accident The anatomy of the extra and intrarenal arteries the size and shape of the kidney and the circulation time was normal (Fig 5 b and c)

Case 5 (Fig 6) Man aged 19 with haematuria following a traffic accident good general condition

Roentgen examination The renal outline could not be identified large soft tissue mass evident

Urography No abnormality on right side Filling was obtained only of the superior calyces which were impressed from below The ureter was patent

Left selective renal angiography 8 days after accident The extra and intrarenal arteries were of normal appearance The kidney was somewhat flattened its outline was smooth There were no signs of renal rupture

Case 6 Man aged 23 with slight haematuria after being injured by a fall of timber Tenderness over the left kidney good general condition

Roentgen examination Kidneys of ordinary size though partly masked by bowel contents Soft tissue mass along the left border of the lumbar spine the transverse processes of all the lumbar vertebrae were fractured On re examination 2 days later the distal part of the left kidney could not be defined

Urography showed no abnormality on the right side but excretion on the left side was poor and the left renal pelvis was incompletely filled



a



b



c

Fig 3 Case 2 a) Urography Good excretion on right side impaired excretion on left side with upward displacement of pelvis and impression of upper part incomplete filling b) Left selective renal angiography 5 days after accident Lower intrarenal arteries slightly displaced outwards and downwards medial capsular artery (arrow) arched medially by capsular haematoma c) Nephrographic phase No signs of rupture



a

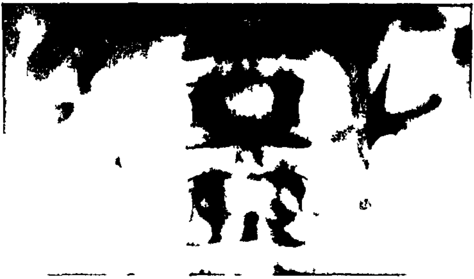


b

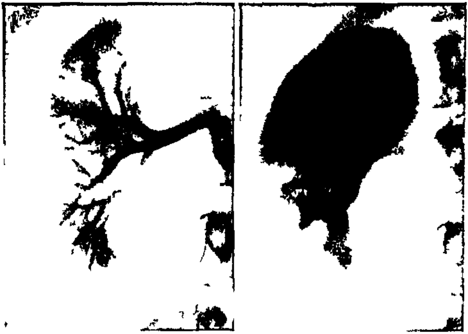


c

Fig 4 Case 3 a) Urography Right kidney not outlined pelvis displaced caudally in complete filling impaired excretion b) Aortic renal angiography 2 days after trauma arterial phase Kidney somewhat rotated with upper pole displaced laterally superior capsular artery (arrows) widely arched cranially except distal part which follows the kidney surface c) Nephrographic phase No signs of renal rupture



a



b c

Fig. [illegible] Case 4. a) Urography. Slightly impaired excretion on right side, incomplete filling of lower calyces and confluence impression in upper part of ureter. b) and c) Right selective renal angiography, frontal views, arterial and nephrographic phases.

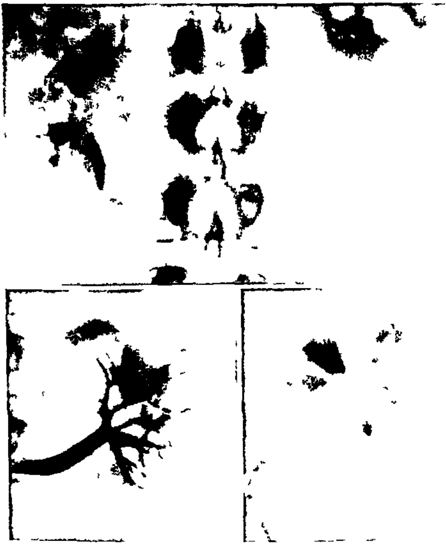


Fig 6 Case 5 *Upper* Urography Loss of retroperitoneal markings on left side fairly good excretion into left pelvis filling only of upper calyces which are displaced upwards and impressed from below ureter patent *Lower views* Left selective renal angiography The arterial phase (left) is normal in the nephrographic phase (right) the kidney is flattened no signs of rupture

Selective and aortic renal angiography 4 days after accident The left kidney was supplied by two renal arteries After selective angiography with injection of contrast medium into each of the renal arteries an injection was made into the aorta The arteries and the size and shape of the kidney appeared to be normal No signs of renal rupture The lower renal pole was displaced slightly laterally

Discussion of group I

The same essential type of changes were found at conventional roentgenography and urography in all 6 cases with a clinical diagnosis of renal rupture The findings were well consistent with the clinical diagnosis of renal rupture according to current roentgendiagnostic criteria

Renal angiography was performed in the acute stage 2, 3 4 5 8 and 15 days respectively after the accident In 5 of the cases the subjects were examined by the selective technique In one case the examination was supplemented by aortic angiography owing to the presence of multiple renal arteries and in one case the subject was examined by aortic angiography only It should be stressed that one projection may not be enough to demonstrate a rupture A fairly large rupture in Case 1 could only be demonstrated with certainty in oblique views In only one of the 6 cases was the examination limited to a single projection namely in Case 5 in which aortic angiography was performed The selective technique is preferable because it requires only small doses of contrast medium gives a selective filling of relevant vessels and offers the best possibility of obtaining informative projections Case 1 also illustrates how necessary it is to demonstrate both the arterial and nephrographic phases Moreover, angiography like all other types of roentgen examinations should never be performed in a stereotype manner but adjusted to suit the requirements of the situation

The angiographic findings may be summarized as follows

In 1 case no signs of any changes were found at angiography In 4 of the cases the kidney was displaced obviously by a perirenal haematoma but no evidence of a true renal rupture could be demonstrated In 2 of these cases one capsular artery was displaced In 1 case the examination revealed the presence and the extent of a renal rupture

The other 5 cases in this group cannot be classified as renal ruptures and, as at the most they were cases of small renal lesions can warrant no conclusion as to healing The changes demonstrable in conventional films and at urography may thus be caused by renal rupture but they may also be due only to a haematoma in the renal sinus or outside the renal capsule with compression of the kidney If no signs of a pathologic condition are found at later control examination of such cases the only conclusion that may be drawn is that the changes in the region of the kidney that produced ambiguous roentgenographic signs have disappeared

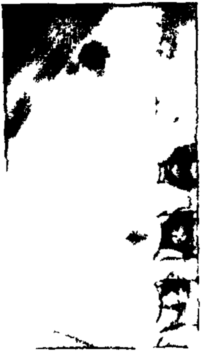
Group II. Sub-acute stage of renal injury

Case 7 Man aged 20 admitted in a state of shock and with haematuria following traffic accident. Immediate exploration revealed a right retroperitoneal haematoma No renal rupture could be [illegible]d He made a rapid primary recovery but 5 weeks later returned with gross haematuria



a b c

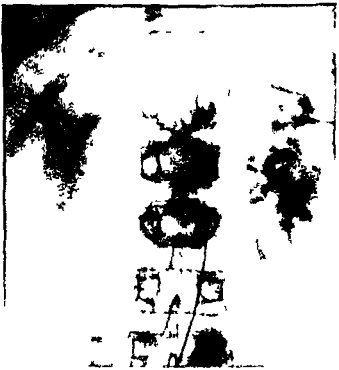
Fig 7 Case 7 a) Urography 46 days after accident Left side normal impaired excretion on right side marked lateral impression and defect in pelvis b) and c) Right selective renal angiography arterial phase frontal view (b) arterial phase lateral view (c) The main renal artery is displaced medially together with the intrarenal branches which are markedly displaced also caudally the superior capsular artery is widely arched upwards large intra and extrarenal haematoma



a



b



c

Fig. 8. Case 8. a) Urography. Large soft tissue mass retroperitoneally on right side, filling of upper calyces only. b) Aortic angiography 3 months after accident. Arterial phase: displacement of proximal part of abdominal aorta to left, marked displacement upwards of renal, suprarenal and hepatic arteries, atrophy of renal artery. c) Nephrographic phase. Only uppermost and lowermost parts of a large right kidney increased in density.



a b

Fig 9 Case 9 Right selective renal angiography 39 days after accident after recovery from severe crush syndrome a) Arterial phase Right renal artery markedly atrophic cranial branch blocked 1 5 cm from its origin in the ventral arterial branch b) Nephrographic phase Low density of kidney parenchyma large filling defect in cranial pole of kidney

Roentgen examination 46 days after accident The right kidney was markedly enlarged

Urography No abnormality on the left side the excretion on the right side was satisfactory A marked impression was seen in the lateral part of the renal pelvis (Fig 7a) Three days later the patient suddenly developed gross haematuria and shock. Emergency laparotomy was performed and a large haematoma evacuated

Right selective renal angiography 2 months after accident The renal artery was slightly narrowed and displaced medially The ventral and dorsal intrarenal branches embraced an expansive lesion at least 10 cm in diameter and were markedly distended and depressed The superior capsular artery was displaced and stretched (Fig 7 a and b) Only slight concentration of the contrast medium occurred in the nephrographic phase and then mainly in the lower pole A large defect was evident in the lateral and superior part of the kidney

Conclusion Large intrarenal and extrarenal haematoma with considerable destruction of renal parenchyma

Operation (G Jonsson) Large retroperitoneal haematoma The renal arteries could be identified with the aid of the angiograms The kidney was lacerated and a further large haematoma extended into the retroperitoneal haematoma Nephrectomy

Case 8 Man aged 18 with haematuria following fall on the right side

Roentgen examination Large soft tissue mass in the region of the right kidney which could not be outlined

Urography (13 days later) Normal conditions on the left side Filling was obtained only of the superior calyces on the right side these were dilated and displaced upwards (Fig 8a)



a b



c

Fig 8 Case 8 a) Urography Large soft tissue mass retroperitoneally on right side filling of upper calyces only b) Aortic angiography 3 months after accident Arterial phase displacement of proximal part of abdominal aorta to left marked displacement upwards of renal suprarenal and hepatic arteries atrophy of renal artery c) Nephrographic phase Only uppermost and lowermost parts of a large right kidney increased in density



Fig 10 Case 10 *Upper* Urography Right side normal left side good excretion lower calyces deformed and stretched towards kidney surface *Lower views* Left selective renal angiography 2 years after accident Arterial phase (left) slight reduction of calber of main renal artery slight widening and tortuosity of intrarenal branches which can be followed close to kidney surface nephrographic phase (right) irregularity in lower pole



a



b

Fig 11 Case 11 a) Urography 13 years after renal injury Compensatory hypertrophy of right kidney small irregular left kidney with intrarenal calcifications good excretion into a small deformed pelvis b) Aortic renal angiography Hypertrophy of right renal artery marked atrophy of left renal artery



Fig 12 Case 11 (see also fig 11) Left selective renal angiography a) Arterial phase Vascularization fairly good in lower third of left kidney marked atrophy of intrarenal arteries in rest of kidney This part of kidney (b) changed into hydronephrotic sac

Case 11 Man aged 40 with hypertension and a clinical diagnosis of renal rupture 13 years previously after a skiing accident

Roentgen examination Enlargement of the right kidney and a small left kidney which was irregular in outline and contained calcifications

Urography Fairly good excretion in the small left kidney with marked deformity of the renal pelvis (Fig 11a)

Aortic renal angiography The left renal artery was markedly narrowed The right renal artery and intrarenal branches were widened (Fig 11b)

Left selective renal angiography on the same occasion (Fig 12) The intrarenal branches in the upper part of the kidney were normal in width but otherwise thin and stretched The parenchyma was of increased density in this region The rest of the kidney appeared to constitute a hydronephrotic sac with a thin capsule of increased density

Conclusion Atrophy of left kidney with hydronephrosis of its lower two-thirds

Case 12 Woman aged 18 with long standing urinary infection and a 3 year-old history of haematuria following a blow in the left flank

Roentgen examination immediately after the accident The left kidney was enlarged and ill-defined. A large mass in the left retroperitoneal space displaced the colon

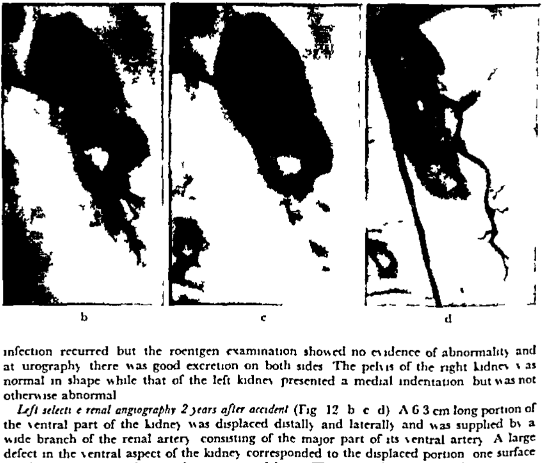
Urography No abnormality on the right side The left upper calyces were dilated and displaced cranially only slight excretion into the lower calyces which were wide and deformed (Fig 13a)

Following three weeks conservative treatment laparotomy was performed and a urinary phlegmon on the left side emptied The patient made a rapid recovery At urography two years later slight deformity of the left renal pelvis was evident Three years later the urinary

Fig 13 Case 12 Old renal rupture with displacement of large ventral portion of kidney and changes consistent with pyelonephritis a) Urography Large soft tissue mass in left retroperitoneal space filling of uppermost calyces only which are dilated b) c) and d) Left selective renal angiography 2 years after accident arterial phase frontal view (b) nephrographic phase (c) arterial phase oblique view (d) Portion of ventral part of kidney displaced distally and laterally and supplied by a wide branch of the renal artery consisting of major part of ventral arterial branch Corresponding to displaced portion a large defect in ventral aspect of kidney cortical part of detached portion irregular and corresponding arterial branches slightly tortuous and widened



a



b c d

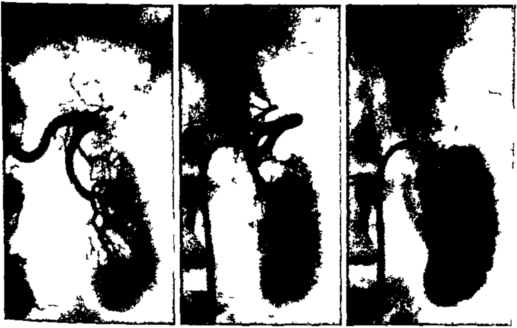
infection recurred but the roentgen examination showed no evidence of abnormality and at urography there was good excretion on both sides The pelvis of the right kidney was normal in shape while that of the left kidney presented a medial indentation but was not otherwise abnormal

Left selective renal angiography 2 years after accident (Fig 12 b c d) A 6 3 cm long portion of the ventral part of the kidney was displaced distally and laterally and was supplied by a wide branch of the renal artery consisting of the major part of its ventral artery A large defect in the ventral aspect of the kidney corresponded to the displaced portion one surface of which appeared to have a distinct cortical layer This cortical part of the fragment was somewhat irregular and the corresponding arterial branches were slightly tortuous and widened The findings thus suggested pyelonephritis



a

Fig 14 Case 13 Sequelae of left renal rupture with displacement of a portion of the renal parenchyma and marked atrophy of the upper part of the kidney a) Check urography 5 years after trauma to left kidney Slight deformity of left renal pelvis b) c) and d) Left selective renal angiography arterial phase frontal view (b) arterial phase oblique view (c) nephrographic phase oblique view (d) Atrophy of intrarenal arteries to lower pole large defect in middle of ventral aspect of kidney surface with a large arterial branch protruding into the defect a portion of the kidney is displaced ventrally and supplied by very narrow arteries



b c d

Conclusion Old renal rupture with displacement of a large ventral portion of the kidney with changes consistent with pyelonephritis

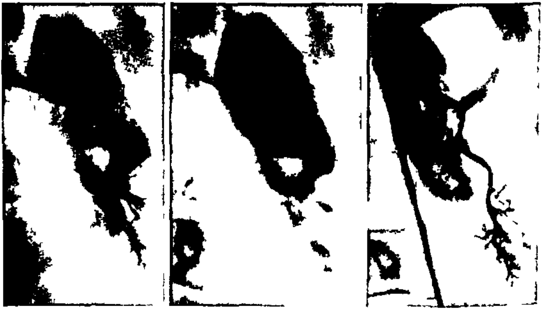
Operation (G Jonsson) confirmed the angiographic findings The displaced part of the kidney was removed Pathologic examination sequelae of pyelonephritis

The patient made a complete recovery



a

Fig 13 Case 12 Old renal rupture with displacement of large ventral portion of kidney and changes consistent with pyelonephritis a) Urography Large soft tissue mass in left retroperitoneal space filling of uppermost calyces only which are dilated b) c) and d) Left selective renal angiography 2 years after accident arterial phase frontal view (b nephrographic phase (c) arterial phase oblique view (d) Portion of ventral part of kidney displaced distally and laterally and supplied by a wide branch of the renal artery consisting of major part of ventral arterial branch Corresponding to displaced portion a large defect in ventral aspect of kidney cortical part of detached portion irregular and corresponding arterial branches slightly tortuous and widened



b c d

infection recurred but the roentgen examination showed no evidence of abnormality and at urography there was good excretion on both sides The pelvis of the right kidney was normal in shape while that of the left kidney presented a medial indentation but was not otherwise abnormal

Left selective renal angiography 2 years after accident (Fig 12 b c d) A 6 3 cm long portion of the ventral part of the kidney was displaced distally and laterally and was supplied by a wide branch of the renal artery consisting of the major part of its ventral artery A large defect in the ventral aspect of the kidney corresponded to the displaced portion one surface of which appeared to have a distinct cortical layer This cortical part of the fragment was somewhat irregular and the corresponding arterial branches were slightly tortuous and widened The findings thus suggested pyelonephritis

SUMMARY

The angiographic appearances in the acute and subacute stages of renal injuries are described. The same urographic or pyelographic changes in the acute stage may signify renal rupture or simply an extra-renal haematoma. No or moderate urographic changes at a late examination after renal trauma do not exclude the possibility of gross renal abnormality demonstrable by angiography.

ZUSAMMENFASSUNG

Die angiographischen Erscheinungen im akuten Stadium und im subakuten Stadium der Nierenverletzungen werden besprochen. Dieselben urographischen Symptome im akuten Krankheitsbild können einer Ruptur oder nur einem einfachen extrarenalen Hämatom entsprechen. Keine oder nur unscheinbare Veränderungen im urographischen Bild im Spätstadium schliessen nicht grobe Veränderungen aus, wie das angiographische Bild zu beweisen vermag.

RÉSUMÉ

Les auteurs décrivent les signes angiographiques des stades aigu et subaigu des traumatismes rénaux. Les mêmes signes urographiques ou pyélographiques au stade aigu peuvent traduire une rupture du rein ou simplement un hématome extra-rénal. L'absence ou la discrétion des signes urographiques à un examen tardif après traumatisme rénal n'excluent pas la possibilité d'une grosse lésion rénale qui peut être mise en évidence par angiographie.

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Addendum

During the preparation for publication of this paper FROST in Fortschr. Röntgenstr. 96 (1962) 260 has presented a case of "Selektive renale Angiographie bei Nierenruptur", which he believes to be the first publication in the literature of an angiographically diagnosed renal rupture. The rupture actually was originally diagnosed at operation and prior to angiography. The accompanying illustrations are from two separate selective catheterizations and show two renal arteries. In the catheterization of the upper renal artery one of the branch vessels was obstructed by spasm. The irregularity of the supposed fragments mainly represents normal anatomy. (See KOHLER: The incomplete angiogram in selective renal angiography. To be published in Acta radiologica.)

FROM THE ROENTGENDIAGNOSTIC DEPARTMENT (DIRECTOR PROF OLLE OLSSON),
UNIVERSITY HOSPITAL OF LUND, SWEDEN

THE POSITION OF THE KIDNEYS

by

HANS MOELL

It was shown in previous investigations (MOELL 1956, 1961) that the normal range of variation of the size of kidneys in adults (20—49 years), as measured in conventional roentgenograms of the abdomen, is fairly wide It was also found that this range was influenced only slightly by body build Interest was focused on the position of the kidneys in these investigations since renal displacement is sometimes the only roentgenologic evidence of a pathologic condition in or near the viscus The recognition of such displacement naturally requires an appreciation of the ordinary position of the kidneys

The adult kidneys are situated in the retroperitoneal space and are supported by an adipose sheath and the tunica fibrosa the adipose sheath is thick over the posterior surface of the kidney but is thin or even absent over the anterior surface The fibrous capsule, a thickening of the retroperitoneal connective tissue encloses the kidneys ventrally and dorsally, the ventral part serving as an attachment for the peritoneum The tunica fibrosa continues as an uninterrupted single leaf to the anterior aspect of the lumbar vertebrae, and this connection together with that to the peritoneum contributes to the fixation of the kidney The adipose capsule is of less importance in this respect but, in the event of partial or complete loss of perirenal fat the capsule will be reduced to a thin sac with consequent increased mobility of the kidney The

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innermost capsule, the tunica muscularis, is made up of thin smooth muscle fibres that are firmly connected with the parenchyma of the kidney but only loosely attached to the connective tunica fibrosa

The right kidney is lower than the left in two thirds of all adults and is situated about 5 to 9 cm from the surface of the skin (HELM 1896) According to RAUBER KOPSCH (1955) the kidneys extend from the level of the upper border of the third lumbar vertebra the right kidney being situated somewhat lower (half to the entire height of a vertebra) In women both kidneys lie somewhat lower (about half the height of a vertebra) than in men but generally do not reach the level of the iliac crest The twelfth rib crosses the kidney obliquely and represents a line of division between the upper third and the rest of the kidney

The upper and lower poles of the kidneys are situated 4 to 5 cm and 6 to 9 cm, respectively, from the midline (RAUBER KOPSCH 1955), CORNING (1931) gives somewhat higher figures of about 7 cm and about 11 cm, respectively The upper pole is nearer the midline than the lower pole and the longitudinal axis passes from a point dorsal, cranial and medial to a point ventral caudal and lateral

Roentgen anatomy The right kidney usually lies lower than the left, as has been observed also at post mortem McCLELLAN (1956) found that in 1 500 consecutive urographies the left kidney was lower in 106 cases or 7 1 per cent in 29 instances the low lying left kidney could probably be attributed either to specific disease or to an anatomic anomaly

The renal arteries usually arise from the aorta at the level of the intravertebral disk between the first and second lumbar vertebra (EDSMAN 1957, BOIJSEN 1959) EDSMAN also found that the centre of the right kidney is projected 0 2 unit cranial to the upper part of L2 and the centre of the left kidney 0 5 unit caudal to the lower part of L1, where one unit is to be understood as one third of the height of the vertebral body The investigation was performed in full expiration

It should be stressed in this connection that the examination should be carried out in the same respiratory phase since the position of the kidneys may vary considerably during the respiratory cycle According to HILGENFELDT (1936) the normal range of migration of the kidney during ordinary, not forced breathing is on the average 17 mm on the right side and 21 mm on the left side in males, and 20 mm and 22 mm, respectively, in females In pathologic processes in or near the kidney these normal transcursions may be changed a roentgenologic observation reported as early as 1907 by HOLZKNECHT & KIENBOCK KOLL (1913) observed that the respiratory migration of the kidneys was reduced in 4 cases of perinephritis abscesses, and in a series of 96 cases of Paranephritiden SKARBY (1946) reported reduction of the migration of the kidneys as an important sign of the condition

Present investigation

The material used for this study of the roentgenographic position of ordinary kidneys in adults was the same as in the previous publication (MOËLL 1961), i.e. 100 males and 100 females between 20 and 49 years of age in which the roentgenologic and clinical examinations showed no abnormalities of the kidneys or urinary tract and there was no history of renal disease. Cases of scoliosis of the lumbar vertebral column were excluded.

The examination was carried out with the subject supine, the beam directed antero-posteriorly and with the central ray about 10 cm cranial to the iliac crest, F.F.D. 100 cm. The exposures were made with the breath held in expiration.

The position of the kidneys is defined as follows: the distances of the cranial and caudal pole of the kidneys from the midline are to be understood as the distances from the midline of the two points used to estimate the length of the kidney, i.e. not necessarily a tangent of the kidney.

The distances upwards and downwards of the kidneys are to be taken as the cranio-caudal distances of the poles of the kidneys as projected on the midline of the vertebral column from the middle of vertebra L 2; the middle of vertebra L 2 is to be understood as the point where an imaginary line along the minimum distance between the lateral parts of the second vertebral body crosses the midline of the vertebral body.

The angle of the kidney is to be taken as the angle subtended by the line used to estimate the length of the kidneys and the midline of the vertebral column.

Conventional statistical methods were used. For further details see MOËLL (1961).

Results

The results of the measurements of the distances from the midline of the cranial and caudal poles of the kidneys and the distances upwards and downwards are given in Table 1. A statistically significant difference was found between the distances of the cranial and caudal poles of the kidneys on each side and in each sex. No such difference could, however, be demonstrated regarding the distances upwards and downwards of the two kidneys.

The angles of the kidneys are given in Table 2. As may be seen, the angles of the kidneys in males are significantly larger (xxx) than in females.

The results recorded in Tables 1 and 2 are represented graphically in Figs. 1, 2 and 3.

A comparison between the two kidneys in the same sex is shown in tabular form in Table 3.

It is clear from the table that the right kidney was lower than the left in both sexes (xxx). No difference was demonstrable between the right and left

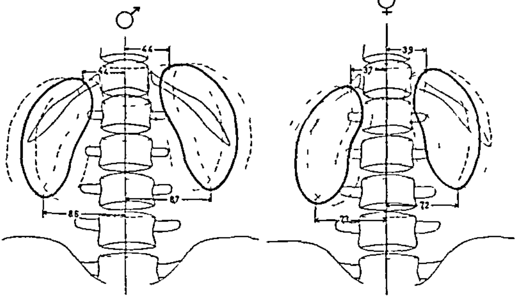


Fig 1 Distances in cm of upper and lower poles from the midline of normal kidneys in males and females Dotted lines indicate ± 2 s

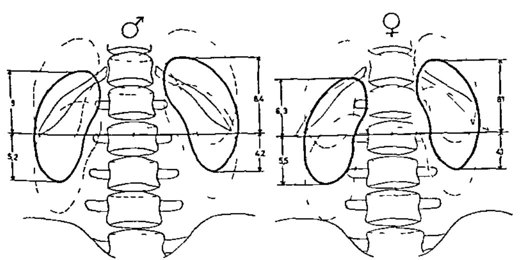


Fig 2 Distances in cm upwards and downwards from the middle of L2 of normal kidneys in males and females Dotted lines indicate ± 2

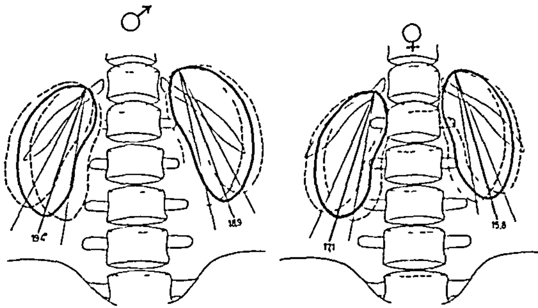


Fig 3 Angles of normal kidneys from the midline in males and females Dotted lines indicate ± 2 s

Table 1

Distances of upper and lower poles of normal kidneys from the midline and distances upwards and downwards of the same kidneys from the middle of L2

	Males		Females		Significance
	Value	s	Value	s	
Distance upper pole right	4.4	0.55	3.7	0.46	xxx
Distance lower pole right	8.6	0.92	7.3	0.79	xxx
Distance upper pole left	4.4	0.61	3.9	0.44	xxx
Distance lower pole left	8.7	0.80	7.2	0.64	xxx
Distance upwards right	6.9	1.69	6.3	2.05	—
Distance downwards right	5.2	1.83	5.5	1.97	—
Distance upwards left	8.4	1.51	8.1	1.45	x
Distance downwards left	4.2	1.51	4.1	1.19	—

Table 2

Angles of normal kidneys from the midline in males and females

	Males		Females		Significance
Angle right	19.4	4.9	17.1	3.6	xxx
Angle left	18.9	3.8	15.8	3.2	xxx

Table 3

Comparison between distances of upper and lower poles upwards and downwards and angles of right and left kidney in males and females

	Right Number	Left Number	Significance	Right Number	Left Number	Significance
Distance upper pole right and left	42	49	—	30	58	xx
Distance lower pole right and left	45	53	—	49	48	—
Distance upwards right and left	11	87	xxx	10	87	xxx
Distance downwards right and left	71	22	xxx	84	15	xxx
Angle right and left	48	52	—	58	41	—

kidney in the distances of the upper and lower poles. In females a difference (xx) as regards the upper pole was found between the right and left kidney. No difference was evident between the angle of the left kidney and that of the right.

SUMMARY

The position of the kidney was determined in conventional roentgenograms in a study of the size of ordinary kidneys in adults. A statistically significant difference was found between the distances of the cranial and caudal poles of the kidneys from the midline on each side. There was also a difference in these distances as well as in the angles of the kidneys in the two sexes. The right kidney generally lay lower.

ZUSAMMENFASSUNG

Während einer statistischen Erhebung über die Grösse von erwachsenen Nieren wurde auch deren Lage im gewöhnlichen Röntgenbild studiert. Bedeutende Unterschiede im Abstand von der Mittellinie für die oberen und unteren Nierenpole auf beiden Seiten wurden gefunden. Unterschiede in den Messergebnissen und in den Achsenwinkeln bestehen für männliche und weibliche Patienten. Die rechte Niere steht normalerweise tiefer.

RÉSUMÉ

Au cours d'une étude sur les dimensions des reins normaux chez l'adulte, l'auteur a étudié sur des radiographies simples la situation des reins. La comparaison des distances des pôles supérieurs et inférieurs à la ligne médiane montre, entre les deux cotés, une différence statistiquement significative. Ces distances ainsi que l'inclinaison des reins diffèrent aussi suivant le sexe. Le rein droit est en général situé plus bas.

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FROM THE ROENTGENDIAGNOSTIC DEPARTMENT (DIRECTOR PROF F KNUTSSON),
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VALUE OF SIMULTANEOUS TOMOGRAPHY IN DEMONSTRATING CALCIFICATIONS OF THE CARDIAC VALVES

by

LARS BJÖRK and HERMAN LODIN

The preoperative demonstration of calcifications of the valves of the heart in valvular disease is of considerable value in the choice of operative procedure as well as in the diagnosis The presence of calcifications is a reliable indication of advanced changes in the valve The only preoperative means of detecting the calcifications is by roentgen examination

Calcareous deposits if large, may be demonstrated in standard projections The deposits are often small, however, and may be mistaken for calcifications elsewhere in the thoracic cavity It may thus not be possible to localize them in standard projections and if very small may not be shown at all

Various means of improving the radiographic demonstration of cardiac valve calcifications have been considered SOSMAN & WOSIKA (1933) SOSMAN (1943), inter alios have recommended fluoroscopy as a reliable method The deposits must be fairly large, however, if they are to be detected and the use of the method calls for wide experience fluoroscopy necessitates long exposure times although the patient dosage may be considerably reduced if an image intensifier and television are employed Cineroentgenography has been advocated for the demonstration of valve calcifications by BARTLEY (1958) and others

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EISLER F Röntgenologische Fortschritte im Bereiche der Physiologie Pathologie und Diagnostik der Harnorgane durch vorwiegende und systematische Anwendung des Durchleuchtungsverfahrens Fortschr Röntgenstr 29 (1922) 1
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One hundred and fifty-one cases that had been operated upon following tomographic examination of the heart for valve defects formed the material for the follow up controls The operations were performed by two thoracic surgeons who paid particular attention to the presence and distribution of calcifications of the valves The calcareous deposits were either detected digitally or observed at instrumental intervention upon the valves Calcifications of the valves were encountered at operation in 40 cases, in 26 of which the deposits had been demonstrated prior to the operation Re examination of the tomograms revealed calcifications in a further three cases Re appraisal of the films disclosed no calcification of the valves in the remaining 11 cases

Simultaneous tomography failed to demonstrate 8 of the 30 calcifications of the mitral ostium and 3 of the 13 deposits in the aortic orifice In the 11 cases in which calcifications were found at operation but were not detected at tomography, the deposits were extremely small and did not exceed 1 to 2 mm in diameter

The investigation suggests that simultaneous tomography performed with the technique described is a reliable method of demonstrating valve calcifications measuring more than 1 to 2 mm in diameter Smaller deposits may, on the other hand, escape detection due of course to their poor density in relation to that of the heart Another factor is blurring caused by movement since exposure times of 1 4 to 2 seconds were used in our series A tomographic technique utilizing shorter exposure times would further improve the diagnostic value of the method

As things are, simultaneous tomography is of considerable clinical value It is sparing to patients in poor condition and is simple and not time consuming in a roentgen department, particularly in one in which the diagnosis of heart disorders forms a major part of the work

SUMMARY

Simultaneous tomography demonstrated calcifications in 29 cases in a material of 40 cases in which calcifications of the valves of the heart were verified at operation The deposits in the remaining 11 cases were less than 1 to 2 mm in diameter

ZUSAMMENFASSUNG

Simultane Mehrschichtenaufnahmen ermoglichten das Aufzeigen von Herzklappenverkalkungen in 29 Fallen von insgesamt 40 Fallen in denen Verkalkung bei der Operation festgestellt wurde In den verbleiblichen 11 Fallen war die Verkalkung kleiner als 1 bis 2 mm im Durchmesser

RÉSUMÉ

Sur une série de 40 cas presentant des calcifications des valvules cardiaques vérifiées a l opération la tomographie simultanée les a montrées dans 29 cas Dans les 11 autres cas les calcifications avaient un diametre de moins d un à deux mm

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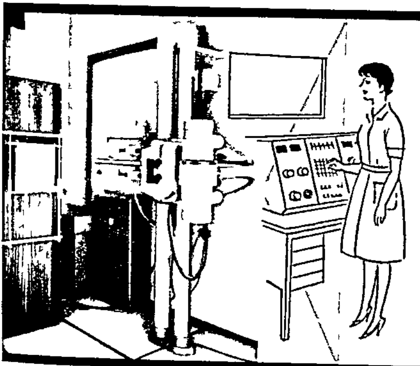
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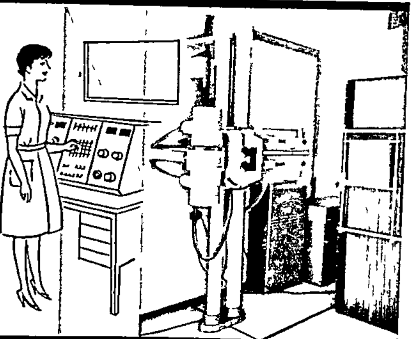
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THE ISOMETRIC RELAXATION PHASE OF THE LEFT VENTRICLE IN MYOTONIA

by

OSBORNE BARTLEY and GUSTAV ÖRNDAHL

Myotonia is defined by DE JONG as 'a disorder of the striated muscle tissue in which the relaxation does not pass off, as it normally does in a fraction of a second but continues for several seconds'. According to the same author the relaxation phase in skeletal muscle may have a duration of as long as 25 to 30 seconds. Myotonia occurs in connection with active movements, but a myotonic reaction can also be elicited by mechanical or electrical stimulation. With repeated movements of the same type in rapid sequence the myotonia diminishes.

Among the morbid conditions with which the myotonic phenomenon is associated in humans are two hereditary diseases: myotonia congenita and dystrophia myotonica.

No specific cardiac signs have been reported in myotonia congenita (SPIL LANE, THOMASEN). In the case of dystrophia myotonica on the other hand the literature contains numerous references to largely asymptomatic electrocardiographic abnormalities consisting of prolonged conduction time or intraventricular conduction disturbances. A few cases with flutter or fibrillation have been recorded (PIPBERGER). Microscopic examination of the heart has occasionally been carried out in cases of dystrophia myotonica. SCHINDLER & FORSTER for instance studied one case in which they observed atrophy of a number of muscle bundles as well as a certain degree of fibrosis and lipoma

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Table 1

Myotonia congenita

Case No	Sex	Age	R R	I R.	Blood pressure	A.C.P	P D	R.A.$_{80}$	n
1	M	81	60.2	14.3	175/95	155	145	10.[illegible]	21
2	M	52	71.4	10.9	115/75	110	100	9.2	19
3	F	51	90.0	12.9	155/105	140	130	10.1	13
4	F	45	88.1	11.7	115/85	110	100	8.6	25
5	M	17	80.0	9.5	95/60	85	75	7.9	10
6	M	32	86.7	11.2	120/85	115	105	9.4	18
Mean			79.4	11.8		119.2	109.2	9.2	
S^2				2.32		504		0.71	

R.R = Duration of preceding heart cycle in 10^{-2} sec
I R.$_{80}$ = Duration of isometric relaxation phase corrected for an R R of 0.80 sec
A C.P = Calculated aortic valve closure pressure
P D = *Difference between A C.P and mitral valve opening pressure*
R A = Relaxation rate of left ventricle $\left(\frac{P D}{I R}\right)$
n = Number of curves examined

tosis Similar observations were made by BENDA & BIXBY in two cases SPILLANE, on the other hand, found no significant myocardial lesions in a patient who had died of a heart attack

Since the myocardium, like skeletal muscle, is striated, the question arises whether the myotonic phenomenon may not be demonstrable in the heart as well We have therefore studied the isometric relaxation phase and the relaxation rate of the left ventricle in patients with myotonia No such investigation has previously been reported

Material The series comprises 14 cases of myotonia, six of which had myotonia congenita (Table 1) and eight dystrophia myotonica (Table 2) They all showed both active and percussible myotonia as well as typical electromyographic findings Five of those with myotonia congenita (Cases 1 to 5 in Table 1) represent three generations Case 1 is the father of Cases 2 to 4, and Case 5 is the son of Case 3 Case 6 is not related to the other myotonia congenita cases Apart from slight hypertension (Cases 1 and 3) the cases presented no signs other than the myotonia

All of those with dystrophia myotonica exhibited, in addition to myotonia the classical symptoms of muscular weakness and atrophy as well as a reduced basal metabolism rate The majority of them also had characteristic symptoms such as testicular atrophy, cataract baldness, and mental deterioration

Table 2

Dystrophia myotonica

Case No.	Sex	Age	R R	I R_{80}	Blood pressure	A.C.P	P D	$R.V._{80}$	n
7	F	27	93.0	10.5	100/70	95	85	8.1	22
8	F	48	71.0	14.0	130/90	115	105	7.5	14
9	M	46	94.8	10.8	110/80	105	95	8.8	10
10	M	33	87.0	11.9	105/80	100	90	7.6	21
11	M	61	60.3	11.9	130/80	115	105	8.8	13
12	F	42	56.4	11.1	120/95	115	105	9.5	10
13	M	46	70.2	11.0	95/70	90	80	7.3	15
14	M	56	69.1	12.6	130/90	120	110	8.7	12
Mean			75.2	11.73		107	97	8.3	
S^2				1.05		104.8		0.50	

For explanation of abbreviations see Table 1

All subjects underwent roentgen examination of the heart and lungs as well as electrocardiographic examination in conjunction with the electrokymographic studies One of the myotonia congenita cases with hypertension (Case 1) had moderate cardiac enlargement due to hypertrophy of the left ventricle the relative heart volume was 490 ml/m² body surface The remaining myotonia congenita cases and all those with dystrophia myotonica had hearts of normal size and configuration, in none of these cases did the relative heart volume exceed 400 ml/m² body surface No pulmonary lesions were detected in the myotonia congenita cases Seven of the 8 cases with dystrophia myotonica however were observed to have reduced movement of the diaphragm and small lamellar atelectatic areas in the lower lobes

Myotonia congenita was in no case associated with demonstrable electrocardiographic abnormalities Four cases with dystrophia myotonica on the other hand exhibited abnormalities in the form of flattened *T* waves in one or more leads (Cases 9, 11, 12 and 14) One of them (Case 14) had, in addition, a prolonged conduction time of 0 24 sec, and two (Cases 9 and 11) had changes indicative of an intraventricular conduction disturbance (QRS duration 0 12 sec) No changes pointing to previous cardiac infarction were noted All cases had sinus rhythm There was in no case a history of subjective symptoms definitely referable to the heart Electrokymographic tracings from the atria the ventricles and the great vessels revealed no abnormalities suggestive of organic heart defects or myocardial lesions

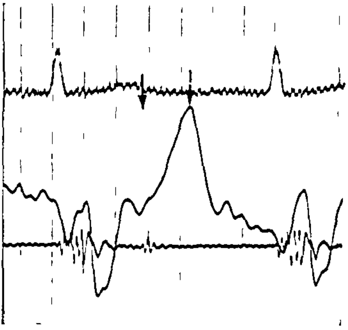


Fig. 1. Electrokymogram from left auricular appendage. Case 8 (dystrophia myotonica). Duration of I.R. between arrows (0.14 sec.)

In addition, two cases with dystrophia myotonica were examined and manifested signs of cardiac insufficiency. Since these cases could not be expected to have a normal mitral valve opening pressure and since they had not been catheterized, they were excluded from the series.

Method. In an earlier investigation (BARTLEY 1960) the isometric relaxation phase of the left ventricle was studied in a group of normal subjects and in a series of cases of various heart diseases. Since the present investigation was conducted, in principle, along similar lines the method and relevant data will be briefly reviewed.

The mode of examination employed was electrokymography, a method by means of which the movements of the heart chambers and the great vessels can be graphically reproduced. The examination is carried out under fluoroscopy and involves the use of a special photocell which is positioned directly over the contour to be examined. The photocell is stationary and the contour moves within the frame of its photosensitive slit. The movement is associated with varying light absorption which is reproduced in the form of a curve. An Elema electrokymograph was employed in this study. The tracings were recorded on an Elema Klinik apparatus concurrently with electrocardiograms (ECG) and phonocardiograms (PCG). The electrokymogram showed a time lag of 0.01 sec. in relation to the ECG and PCG.

According to definition the isometric relaxation phase (I R) begins on the left side with closure of the aortic valve and terminates with opening of the mitral valve The aortic component of the second heart sound coincides with closure of the aortic valve The onset of the isometric relaxation phase on the left side can thus be determined from the phonocardiographic tracing When the mitral valve opens a medial movement of the left atrium takes place beginning in the auricular appendage simultaneously with the valve opening In our studies the termination of the isometric relaxation phase was thus determined on the basis of electrokymograms from the left auricular appendage (Fig 1)

The duration of the isometric relaxation phase both in normal subjects and in pathologic cases, depends upon several factors including the intra aortic pressure on aortic valve closure (A C P), the left atrial pressure on mitral valve opening and the relaxation rate (R V) i e the rate at which the left ventricular pressure falls during the isometric relaxation phase Importance attaches also to other factors, chief amongst which is the duration of the immediately preceding cardiac cycle A low pressure on aortic valve closure, a high pressure on mitral valve opening, a high relaxation rate, and a preceding cardiac cycle of short duration, serve to reduce the duration of the relaxation phase, and vice versa Since a linear correlation exists between the duration of the immediately preceding cardiac cycle and the isometric relaxation phase the heart rate can be corrected for any given relaxation phase and the values for subjects with different heart rates thus compared In this study the duration of the isometric relaxation phase was related to a duration of 0 80 sec for the immediately preceding cardiac cycle ($I R_{80}$)

The aortic valve closure pressure was determined as follows In conjunction with each electrokymographic examination the systolic and diastolic pressures were obtained with a conventional blood pressure cuff and checked against a mercury manometer Electrokymograms were taken from the ascending aorta and aortic arch in each subject (These tracings are similar in form to pressure curves from the aorta) The highest and lowest points on the aortic tracings were assumed to represent the systolic and diastolic pressures respectively The position of the incisura was determined on the aortic curve in relation to the highest and lowest points and was assumed to represent the aortic valve closure pressure

Under normal conditions the mitral valve opening pressure is approximately 10 mm Hg Since no signs or symptoms of left ventricular failure or of organic heart defects were present in any of our cases it was assumed that all subjects had a normal mitral valve opening pressure of 10 mm Hg During the isometric relaxation phase the left ventricular pressure falls from the pressure at aortic valve closure to that of mitral valve opening This pressure difference (P D) is thus equal to the aortic valve closure pressure less 10 mm Hg The relaxation rate of the left ventricle during the isometric relaxation phase was defined as

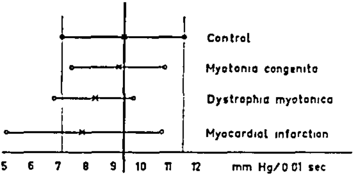


Fig 2 Relaxation rate of left ventricle (RV_{80}) Group means (×) and ranges (o—o) with 95 % confidence limits (Controls and myocardial infarctions from Bartley 1960)

the pressure decrease in millimeters of mercury per 0 01 sec, and was accordingly determined from the formula PD/IR_{80} This relaxation rate, corrected for a preceding cardiac cycle duration of 0 80 sec, is here termed RV_{80}

The error of measurements on electrokymograms did not exceed 0 01 sec Statistical analysis was based on the *t* test

Normal values Under normal conditions the duration of IR_{80} is almost constant, varying only between 10^{-2} and 13^{-2} seconds The mean RV_{80} is 9 4 mm Hg/0 01 sec The range of variation for a 95 per cent confidence interval is 7 2 to 11 5 mm Hg/0 01 sec

Results

The results are collected in Tables 1 and 2 From the first table it is evident that Case 1 had a longer, and Case 5 a shorter relaxation phase than the normal subjects The mean for the group is $11\ 8^{-2}$ sec In all cases the relaxation rate is within the normal range, and the mean of 9 2 mm Hg/0 01 sec is normal

Seven of the eight cases with dystrophia myotonica showed a relaxation phase of normal duration in the eighth (Case 8) the duration was prolonged Although the relaxation rate in the individual cases was within the normal range the group mean of 8 3 mm Hg/0 01 sec differed by a highly significant margin from that of 9 4 mm Hg/sec for the normal subjects (Fig 2)

Discussion

Myotonia as was stated, is associated with greatly prolonged relaxation of skeletal muscle A corresponding prolongation of the relaxation phase of the left ventricle can a priori be ruled out for two reasons first, prolongation of that phase even by a few tenths of a second would, due to abnormal shortening

of the ventricular filling phase, preclude effective emptying of the atrium, secondly, the heart muscle performs repeated identical movements in rapid sequence. Corresponding activity in skeletal muscle entails a diminution or disappearance of the myotonic phenomenon. Theoretically, however, a certain myotonic phenomenon in heart muscle cannot be summarily rejected. Myotonia occurs both in myotonia congenita and in dystrophia myotonica, yet these two morbid conditions differ with respect to the myodystrophic component, which is not found in myotonia congenita cases.

Four of our six myotonia congenita cases had normal I.R.$_{60}$ values. In Case 1 the I.R.$_{60}$ was abnormally long and in Case 5 it was somewhat short. The prolongation in Case 1 could be fully accounted for by the presence of hypertension associated with the high pressure on aortic valve closure. Case 5, on the other hand, had a conspicuously low pressure on aortic valve closure which might have been entirely responsible for the shortened I.R.$_{60}$. Seven of the dystrophia myotonica cases exhibited normal I.R.$_{60}$ values, the eighth (Case 8) had an abnormally prolonged relaxation phase even though there was no elevation of the aortic valve closure pressure. All the myotonia cases had a mean I.R.$_{60}$ value somewhat higher than that for the controls (11.0^{-2} sec) although the difference was not statistically significant. In myotonia congenita, the aortic valve closure pressure, and the difference between pressures at aortic valve closure and mitral valve opening (P.D.), were somewhat higher and in dystrophia myotonica somewhat lower than in the control series (113.5 and 103.5 mm Hg respectively) but neither of these differences was statistically significant. The fact that I.R.$_{60}$ was slightly longer in myotonia congenita than in the control group may, however, have been entirely attributable to the somewhat higher A.C.P. and P.D. values.

The relaxation rates (R.V.$_{60}$) for the individual cases of myotonia congenita and dystrophia myotonica were within the normal range. The group mean for the former likewise showed no deviation from normal, but differed significantly from that of the dystrophia myotonica cases (8.3 mm Hg/0.01 sec). The latter value in turn differed by a highly significant margin from the group mean for the controls. Dystrophia myotonica is thus associated with an abnormally low relaxation rate of the left ventricle (Fig. 2). The rate is not so low, however, as that for myocardial infarction cases (7.9 BARTLEY 1960). Since the myotonia congenita cases had a normal relaxation rate the low rate in the cases of dystrophia myotonica cannot have been attributable to a myotonic phenomenon, hence it was probably due to myocardial lesions. The question as to whether such lesions are caused by coronary sclerosis or by the presence of a dystrophic component in the heart muscle cannot be resolved without autopsy examination of the myocardium. Cases of dystrophia myotonica both with dystrophic affectation of the heart muscle (WRAGE & MERTENS, BLACK & RAVIN) and with coronary sclerosis (WOHLFART, THOMASEN, SLATT) are recorded in the literature.

The assumption that myocardial lesions are responsible for the low relaxation rate in dystrophia myotonica cases is corroborated by the frequent observations of electrocardiographic abnormalities indicative of prolonged conduction time and intraventricular conduction disturbances The literature contains no references to similar abnormalities in myotonia congenita, nor were any such changes noted in our myotonia congenita cases

Lastly, an anatomic difference exists between skeletal and heart muscle Although both are striated each myofibril in normal skeletal muscle has an end plate (COERS & WOOLF) whereas heart muscle fibrils lack end plates COERS & WOOLF, and MAC DERMOT, have demonstrated in myotonia cases multiple end plates for each myofibril This discrepancy between the numbers of end plates in healthy and in myotonic skeletal muscle may account for the active myotonic phenomenon (ÖRNDAHL) The absence of end plates in cardiac muscle fibrils would accordingly preclude a myotonic phenomenon in the heart

SUMMARY

The isometric relaxation phase and the relaxation rate of the left ventricle were determined in 14 cases of myotonia 6 of which had myotonia congenita and 8 dystrophia myotonica The relaxation rate was found to be abnormally low in the latter group but within the normal range in the former The low relaxation rate observed in the cases of dystrophia myotonica is assumed to have been attributable to myocardial lesions

ZUSAMMENFASSUNG

Die isometrische Relaxationsphase und der Relaxationsverlauf des linken Ventrikels wurden in 14 Fallen von Myotonie bestimmt wobei es sich in 6 Fallen um Myotonia congenita und in 8 Fallen um Dystrophia myotonica handelte Man fand dass der Relaxationsverlauf in der letzten Gruppe abnormal langsam ist in der ersten Gruppe jedoch innerhalb normaler Grenzen liegt Der langsame Relaxationsverlauf der bei Fallen von Dystrophia myotonica beobachtet worden war durfte ein beitragender Faktor zu Myocardlasionen sein

RÉSUMÉ

Les auteurs ont mesuré la phase de relaxation isométrique et le temps de relaxation du ventricule gauche dans 14 cas de myotonie dont 6 avaient une myotonie congénitale et 8 une dystrophie myotonique Ils ont constaté que le temps de relaxation est anormalement court dans le deuxième groupe mais qu il est dans les limites de la normale dans le premier groupe Ils pensent que la brièveté du temps de relaxation observée dans les cas de dystrophie myotonique est attribuable a des lésions myocardiques

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ANGIOGRAPHY IN EPIDURAL HAEMATOMAS

by

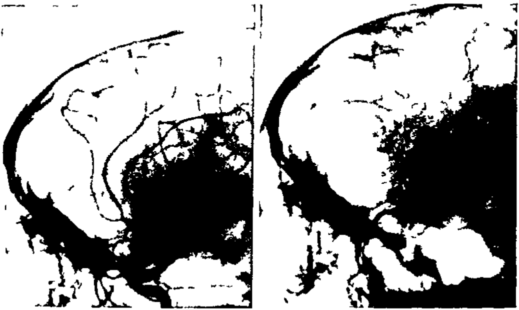
STEN CRONQVIST and ROLF KOHLER

It is recognized that the differential diagnosis between an epidural haematoma and a subdural haematoma, intracerebral haematoma, or expansive growth, may be difficult and sometimes impossible The aim of the investigation now reported was to establish criteria upon which the diagnosis of epidural haematomas could be established The study is based upon the examination of conventional roentgenograms of the skull and 31 carotid angiograms in 25 cases in which such haematomas were found at operation

The 31 angiographies were performed by percutaneous puncture The common carotid artery was punctured in 8 instances and the internal carotid artery in the remainder Three lateral views, representing the arterial, capillary and venous phases and two films in the a p projection, representing the arterial and venous phases were usually obtained, and, in addition tangential views of the surface of the brain to show its relation to the vault of the skull Serial angiography with runs of about 10 seconds have lately been employed

The main localization of the haematoma, that is to say its deepest part, was found at operation to be frontal in 4 cases temporal in 12, parietal in 6 (in two of these cases haematomas were found bilaterally) and occipital in one case, in 2 cases the haematoma covered the whole convexity There were, however, often no distinct borders and haematomas situated over the lateral surface of the temporal lobe showed a tendency to spread upwards over part

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a b

Fig 1 Frontal epidural haematoma tangential view Displacement of arteries (a) and veins (b) in relation to calvarium

of the parietal region In 7 cases the haematomas were combined with contusion of the brain tissue and in one case with generalized oedema of the brain

Conventional roentgen examination of the skull was performed in 23 of the 25 cases Fracture on the same side as the haematoma was evident in all the cases In most cases the main situation of the haematoma corresponded roughly to the site where the fracture crossed a vascular groove

Cerebral contusion was evident as an additional finding at operation in 3 cases of the 4 cases of frontally localized epidural haematomas A completely avascular area between the vault of the skull and the surface of the brain was present in one case (Fig 1) In the remaining 3 cases in which a contusion was found there were signs of an expansive process with characteristic changes (Fig 2) A marked degree of decreased vascularity was noted in the anterior part of the frontal lobe in sharp contrast to the brain tissue posteriorly this was best noted in the early capillary phase (Fig 2c) In 2 cases the border between the two areas was accentuated by veins that were arched with their convexities backwards (Fig 2d) The pericallosal artery was displaced back wards as well as over the midline (Fig 2 a and b) The middle cerebral artery was displaced backwards somewhat laterally and downwards and the carotid siphon was compressed (Fig 2b) Smaller arteries projecting frontally were stretched and separated However in these three cases no avascular zone could

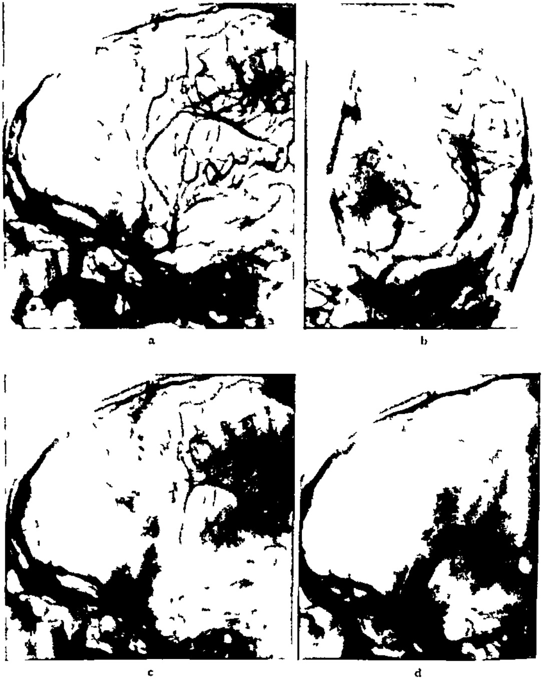


Fig 2 Frontal epidural haematoma with contusion a) Lateral projection pericallosal artery displaced backwards frontally directed arterial vessels separated and stretched with few vessels anteriorly b) A p projection arch formed displacement of pericallosal artery slight lateral shift of first part of Sylvian vessels c) Lateral late arterial phase area of decreased vascularity with sharp border lies in front of one of slightly increased density d) Venous phase arch like deformed veins at the border between the two areas



a



b



c

Fig 3 a) Epidural haematoma lateral to and below anterior part of temporal lobe no avascular area visible displacement of branches of external carotid artery (arrows) b) and c) Ap and lateral projections in a case of haematoma with localization as in (a) Displacement of branches of external carotid artery (→) extravasation of medium from ruptured artery (—▸)

be separated from the area with decreased vascularity and thus no changes typical of an epidural haematoma were evident

Haematomas were situated in the temporal region in 12 out of the 25 cases, with the angiographic appearances differing according to their relation to the *temporal lobe Two distinct groups could thus be separated epidural haema* tomas situated beneath the temporal lobe (5 cases), and haematomas lying over the lateral aspect of the lobe (7 cases)

In the first group one of the characteristics of epidural haematomas, the avascular area, was often difficult to diagnose with certainty Skeletal parts as well as vessels reaching the surface of the brain more posteriorly often obscured the lesion although displacement of the arteries in the Sylvian fissure was marked The peripheral part of the middle cerebral artery or the whole artery was displaced upwards and medially, and corresponding changes in the position of the anterior part of the Sylvian vessels were also noted, upward displacement being most evident Smaller vessels running laterally were stretched and displaced, with a tendency to formation of arches with the convexities upwards (Fig 3a) The carotid artery before its division was in some cases displaced *medially and stretched The pericallosal artery was shifted to the opposite side* but the degree of displacement was far less than that of the first mentioned arteries e g the middle cerebral artery Changes of the type described were noted also in the course of the veins In 3 of the 5 cases belonging to this group the puncture had been made in the common carotid artery with consequent contrast filling of the external vessels In these three cases external vessels crossing the anterior aspect of the middle fossa were seen to be raised medially and to run in a bow with the convexity pointing upwards and medially (Fig 3 a and b) A rupture of one of these vessels with contrast medium outside its wall was also noted in one case (Fig 3c)

In the other group of epidural temporal haematomas, those situated lateral to the lobe, the avascular area was easier to define and in the most typical cases the haematoma was well demonstrated (Fig 5) Vessels reaching the surface of the brain in adjacent but not displaced regions in some cases more or less obscure the avascular area The value of tangential films over the anterior and posterior aspects of the skull then become evident The haema tomas in this region were often fairly deep with the border directed towards the brain surface straight or convex In 4 of the cases a displaced superficial vein defined the medial border of the haematoma in spite of other overlapping vascular structures The middle cerebral vessel was pushed medially only when the haematoma stretched far forwards Medial displacement of the Sylvian vessels was the rule *The pericallosal artery* as *well* as *the internal cerebral vein* were displaced to the opposite side but the shift did not correspond to the dis placement of the brain surface or of the Sylvian vessels except in 4 cases There was also displacement of the Sylvian vessels exceeding the thickness of the haematoma in these four cases, as well as a certain displacement upwards

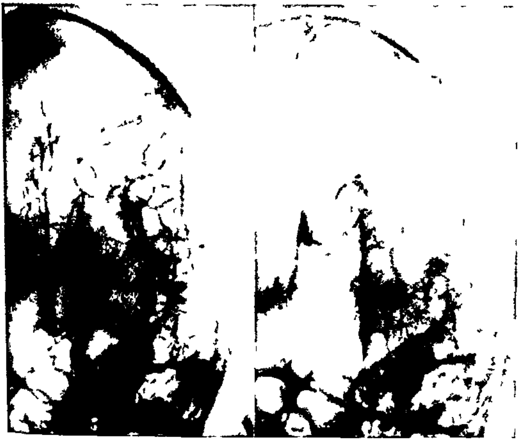
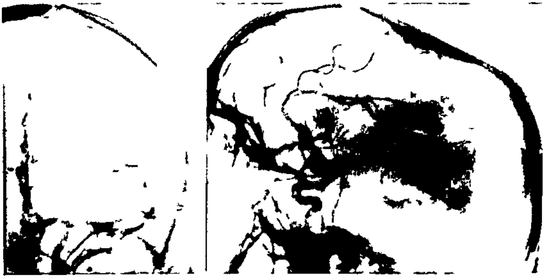


Fig 5 Large haematoma over lateral aspect of temporal lobe oblique projection medial border of haematoma marked by superficial vein

of those vessels Roentgenologic evidence of intracerebral bleeding or contusion was thus also present no bleeding was found at operation In one case with filling of the external carotid artery a displacement of one of its branches of the type earlier described was demonstrated As has been stated temporal haematomas laterally situated may spread over the surface of the parietal region and this was shown angiographically by the avascular zone stretching up over the parietal lobe

There were 6 cases with 8 parietal haematomas in the material Two of these were very shallow and the underlying surface of the brain retained its normal convex form The lesion did not however extend over more than a small part of the convexity and in both cases a large epidural haematoma was found on the opposite side The roentgenologic findings in the other 5 cases of haematomas did not differ much from the one described in connection with



a b



c

Fig 6 Parietal epidural haematoma (a) a p and (b) lateral Only slight displacement of pericallosal artery arteries of Sylvian group separated posteriorly and displaced forwards and downwards (c) Tangential view of well defined haematoma

the lateral temporal haematomas excepting as regards localization (Fig 6) Displacement of the midline vessels did not thus correspond to the depth of the haematoma but, as could be expected the more posterior the haematoma the more obvious was the displacement of the cerebral internal vein compared to that of the pericallosal artery The medial displacement of the posterior parts of the Sylvian vessels was well demonstrated in the angiograms, and in the lateral views were seen to be somewhat separated and pushed slightly forwards The avascular area between the brain and the skull was well defined and in some cases delimited medially by a vein running an arch like course

with a medial convexity The area was best demonstrated in tangential views of the posterior part of the skull (Fig 6c) In one case in which the common carotid artery had been punctured the medial surface of the haematoma was outlined by a displaced branch from the external carotid artery (Fig 7)

No displacement of the midline structures was evident in the one case of an epidural occipital haematoma but the most posterior branches of the Sylvian vessels appeared in the lateral films to be separated and pushed forwards The diagnosis was verified by tangential films which revealed a well defined thick avascular area in the occipital region

An epidural haematoma covering most of the convexity of the brain was present in two cases, it measured 3 cm in depth in one case and 4 cm in the other An avascular area was evident and was accompanied by marked medial displacement of all the Sylvian vessels in both cases

Discussion

Fracture of the skull with a lesion of the dural vessels may give rise to an epidural haematoma The vessels most often affected are the larger branches of the middle meningeal artery The high arterial pressure will cause a rapidly growing haematoma which will spread by dissecting the dura from the inside of the skull

There are two angiographic changes which are of diagnostic value (1) an avascular area and (2) displacement of vessels The existence of an avascular area between the brain and the vault as a sign of extracerebral bleeding was pointed out by LOHR (1936) Many authors have been of the opinion that the differential diagnosis between the two forms of extracerebral haemorrhage, subdural and epidural bleeding is hardly possible (WICKBOM 1949 ENGESET 1950) An exception should according to WICKBOM be those cases in which an epidural haematoma displaces the superior longitudinal sinus from the vault The same appearance of the sinus has however also been noted in normal cases and consequently may not be described as a characteristic sign of epidural haematoma (FRIEDMANN et coll 1959) No case with a displacement of the sinus was found in our cases

NORMAN (1956) published a study on the angiographic differentiation between extradural and subdural haematomas He pointed out that cases of probable extracerebral haematoma are usually examined in close relation to the injury and that the main differential diagnosis then lies between an extra dural and a recent subdural haematoma He showed that the form of the avascular area differed in acute subdural and epidural haematomas The former were found to be rather wide spread and to form a thin layer between the vault and the brain with the convexity of the brain still preserved Epidural haematomas were usually well delineated and produced a local expansion of the same type as evident in chronic subdural haematoma the medial border of the avascular area thus bulged medially



Fig 7 Parietal epidural haematoma concave inner surface of haematoma bounded by displaced branch from external carotid artery (arrows)



Fig 8 Subdural haematoma displacement of pericallosal artery to the same extent as the surface of the brain



Fig 9 Contusion of anterior part of temporal lobe displacement of middle cerebral arteries Smaller arteries of temporal lobe separated and stretched

As an epidural haematoma is most often well localized it may be concealed by vessels lying anteriorly or posteriorly to it Tangential films are therefore of the utmost importance not only to localize the bleeding but to determine its shape (LINDGREN 1954) The differential diagnosis may sometimes of course lie between a chronic subdural and an epidural haematoma The expansive avascular area is identical It appears from our material, however, that an eventual displacement of the pericallosal artery may be of diagnostic value in such cases Thus even in fairly large epidural haematomas, situated in a region where involvement of the pericallosal artery might be expected that is over the lateral region of the temporal lobe and over the anterior aspect of the parietal lobe, the displacement of the pericallosal artery did not correspond to that of the brain surface On the other hand, a fairly good correlation between the displacement of these structures is the rule in chronic subdural haematomas (Fig 8) The most probable explanation of this is that a certain time is needed for a distant effect on the midline structures to become apparent An extra cerebral haematoma, when situated over the occipital parietal, or lateral region of the temporal lobe, may be easily found and differentiated by the technique described and the diagnostic criteria laid down No haematomas with these localizations were missed in this material and the findings were in most cases in accordance with those described by NORMAN The avascular area had a form similar to that caused by an acute subdural haematoma only

in 2 cases It was, however, well localized and covered only a small part of the convexity There are however still haematomas, such as those situated in the anterior fossa or at the bottom of the middle fossa which may be difficult to differentiate Of the 4 cases of frontal haematoma, a true avascular area was present in one in the 3 remaining cases in which contusion was present, the changes accompanying this process were in some respects similar to those caused by an epidural haematoma and differentiation was not possible

The displacement of the larger arteries in haematomas at the bottom of the middle fossa is the same as that evident in cases of bleeding within the anterior part of the temporal lobe or in avascular tumours of this region An avascular area is often difficult to demonstrate due to overlapping skeletal parts and masking by adjacent vessels It seems however, that the form and course of the smaller arterial vessels arising from the lateral part of the medial cerebral artery and normally projecting laterally and towards the inferior part of the temporal lobe, differ in appearance in intracerebral expansive processes and extracerebral haematomas In the former they are stretched and displaced and separated from each other (Fig 9), in the latter no such separation is evident but the vessels have a tendency to be displaced medially and upwards forming arches with their convexities downwards and outwards Another helpful sign is the course of vessels emanating from the external carotid artery This artery was filled in 8 cases, in 5 of which meningeal branches had been displaced from the skull and formed a medial convex arch In one case there was also extravasation of contrast medium from the torn meningeal artery Such an extravasation has been previously observed (LINDGREN 1954 TIWISINA & STECKER 1959)

The existence of a fracture of the skull, especially if it runs close to where the meningeal arteries are known to pass are in favour of a diagnosis of extradural haematoma Thus in our material fractures were present on the side of the haematoma in the majority of cases (23 out of 25) It may be mentioned for comparison that in a series of 107 subdural haematomas fractures were present in 16 cases and in only 9 of these were they situated on the side of the haematoma (LOEW & WUSTNER 1960) Extracerebral bleeding as stated in connection with a haematoma in the temporal region is often accompanied by contusion and haemorrhage of the brain Such damage is revealed at angiography by displacement of the larger arteries exceeding that of the brain surface

Conclusion

Conventional roentgenography of the skull combined with angiography based on the criteria discussed will permit a diagnosis of an epidural haematoma in the occipital, parietal and lateral aspect of the temporal region Haematomas situated in the anterior fossa may have an avascular area but a differential diagnosis between a co-existing intracerebral contusion or haemorrhage is

impossible. Haematomas below the temporal lobe may be difficult to differentiate from expansive processes within the lobe or from subdural haematomas. The smaller vessels in this region may be of diagnostic help and may present an arch like deformity in extracerebral haematoma. As an avascular area in this region is not usually defined the differentiation of a subdural haematoma may be difficult. Angiography of the external carotid artery may be of value in demonstrating displacement of branches of this vessel from the skull or even their injury.

SUMMARY

The angiographic appearances in 25 cases of epidural haematoma are described and the diagnostic criteria considered. Attention is directed to the difficulties that may be encountered especially when the lesion is situated below the temporal lobe or in the anterior fossa. The value of angiography via the external carotid artery is pointed out.

ZUSAMMENFASSUNG

Die angiographischen Erscheinungen beim subduralen Hämatom in 25 Fällen wurden im Einzelnen studiert. Schwierigkeiten in der Diagnose bestehen, wenn die Veränderungen unter dem Temporallappen oder in der vorderen Schädelgrube liegen. Die Bedeutung der Füllung der Carotis externa wird hervorgehoben.

RÉSUMÉ

Les auteurs décrivent les signes angiographiques dans 25 cas d'hématome extra-dural et en étudient les critères diagnostiques. Ils attirent l'attention sur les difficultés que l'on peut rencontrer en particulier quand l'hématome est situé au dessous du lobe temporal ou à l'étage antérieur du crâne. Ils soulignent l'intérêt de l'angiographie de la carotide externe.

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GAS MYELOGRAPHY BY THE LUMBAR ROUTE

by

M ROTH

The exploration of the intracranial spaces by means of negative contrast media and the examination of the intraspinal structures by positive contrast media appear to have become universal standard procedures The relative merits of the positive and negative contrast media have for long been argued There can be no doubt that gas constitutes the ideal biologic medium although its intraspinal application entails certain technical difficulties Tomography would appear to be essential although conventional roentgenography especially in gas myelography of the cervical region, has been employed with success A number of simple methods of cervical gas myelography have been proposed and are used as a routine procedure (JIROUT 1956 LEWIT 1960 and others) Negative myelography of the whole spine as a routine diagnostic method was pioneered by the Swedish school and adopted by a number of investigators (BONTE DELFOSSE & CECILLE 1960, DECKER 1960 JIROUT 1956 inter alios) but does not appear to have been generally accepted

Our present technique was developed following trials that included tomography of a case on a horizontal table that could not be tilted to the Trendelenburg position The myelogram obtained (Fig 3) was of impressive quality and showed severe atrophy of the cord in a woman of 78 years The technique that is now described was eventually standardized as a routine procedure in our institution

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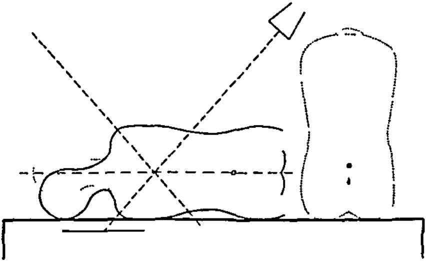


Fig 1 Positioning of the patient

The patient is placed seated on the table as for conventional cervical negative contrast myelography by the JIROUT method i e with the head and neck flexed so that they lie horizontal (Fig 1) The fluid air exchange is accomplished by lumbar puncture which makes the more delicate procedure of suboccipital puncture unnecessary After the CSF pressure has been recorded the whole of the spinal fluid is allowed to drip away

In patients without demonstrable block in the spinal canal the quantity of fluid evacuated usually amounts to between 45 and 55 ml frequently less and exceptionally more We do not adopt the technique of fractionary withdrawal of fluid with simultaneous insufflation of air in view of the subsequent manoeuvring of the patient during which the air might escape into the intracranial spaces We are aware that this is a weak point in our technique but in view of the thorough neurologic examination that always precedes the myelography the possible risk of the massive evacuation of fluid is disregarded

As soon as evacuation is completed the patient is placed on his side with the needle left in situ and the spine running roughly parallel with the plane of the table If the dorsal or lumbar regions of the spinal canal are being investigated the head of the patient hangs over the shoulder and rests on the table If on the other hand the examination is to be confined to the cervical region a pad is inserted between the patient s head and neck and the surface of the table Air is then injected under continuous pressure recording until about 10 to 30 ml more than the fluid evacuated have been introduced the intraspinal pressure at the end of the insufflation amounting to 400 to 600 mm H_2O (Claude) A pressure of up to 500 mm is usually sufficient we prefer not to exceed the maximum pressure recorded in the spinal canal under physiologic conditions i e measured by Queckenstedt s and Stookey s tests The insufflation of extremely large amounts of air although generally well tolerated is not justified since the pressure is increased without any corresponding increase in the volume of the sac This is exemplified by the intraspinal pressure curve recorded in the course of the insufflation (Fig 2) At the moment when the amount of the air injected begins to exceed that of the fluid evacuated the pressure which has been slowly rising to pre evacuation levels shows a rapid increase indicating that the limit of distensibility of the membranous sac has been reached

A conventional film and a pilot tomogram are first obtained In the majority of cases the gas filling achieved is satisfactory and there is no need for additional insufflation apart from the introduction of some 10 to 20 ml air to re establish the pressure which may in the mean

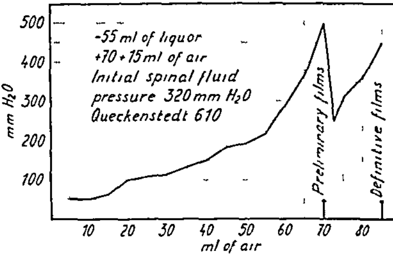


Fig 2 Intraspinal air pressure curve

time have fallen to pre-evacuation levels The main examination consisting of tomography with 4 to 5 median and paramedian cuts about 0 5 cm apart is then performed

Pneumomyelograms obtained in the lateral projection are most informative Supine views also may be helpful for these the patient is placed supine on a pad so that the ... is kept hyperextended and the air prevented from escaping into the intracranial spaces

The rate of insufflation is a factor that seems to exert a decisive influence upon the reaction of the patient to the examination The introduction of air was in the development stages completed relatively quickly but accumulated experience taught us that the slower the insufflation the better the tolerance Presumably the ideal rate of insufflation would be the one practiced in ... encephalography viz 1 to 2 ml air per minute although this would ... require too much time if strictly observed in gas myelography, we proceed therefore with the insufflation in such a way that the desired overpressure ... reached not earlier than in about 15 to 20 minutes With this technique ... frequency and intensity of symptoms have been reduced and in ... not differ from the sensations experienced in the course of an average ... encephalography For the greater part the patients undergo the exam ... without particular distress except for a dull sensation of pressure in the ...

The cause of better toleration of slow insufflation seems to be found ... in the time factor facilitating the establishment of a new pressure equilibrium within the subarachnoid space it would appear that the gas enters the ... cranial liquor spaces in horizontal position far less readily than generally ...

Our first case examined with the technique described had no ... during the procedure although the entire cervical subarachnoid ... abundantly air filled (Fig 3) and a massive penetration of gas into the ... cranial spaces appeared inevitable



Fig 3 Cervical gas myelogram with the patient horizontal Diffuse atrophy of the cord



Fig 4 Neurofibroma at C3—4 Cisterna magna filled but gas does not enter basal cisterns

In another case of a juxtamedullary neurofibroma at the level C3—4 in the ventral subarachnoid space there was no trace of air in the basal cisterns despite complete gas filling of the cisterna magna (Fig 4)

A young woman was investigated for obscure clinical signs which proved later to be caused by a fibrous band compressing the right brachial plexus, in spite of the spinal air filling (Fig 5a) only a minimal amount of gas escaped intracranially into the ambient wing cistern (Fig 5b) More extensive air filling of the intracranial fluid spaces sometimes occurs, however

If the gas enters mainly the ventricular system (Fig 6) subjective symptoms like those known from lumbar encephalography do not appear In the minority of cases only diffuse air filling of the intracranial cisternal spaces takes place and the symptoms do not differ essentially from those complained of when the gas is similarly distributed during encephalography



b



a

Fig 5 Good spinal air filling (a) but only a minimal amount of gas in the ambient wing cistern (b)

A massive and regular thickening of the cord caused by an extensive intramedullary astrocytoma, and marked widening of the cisterna magna resulting from pooling of the cerebrospinal fluid are shown in Fig 7

The thoracic ventral subarachnoid space with the smooth outline of the cord is usually well demonstrated with the technique described An expansive lesion in this region will be clearly shown, and its relations to the cord and coverings may be accurately defined

If the expansive process is situated near the lateral wall of the spinal canal a narrowing, or even obliteration of the ventral subarachnoid space may be observed at the same level and suggest the presence of an intramedullary process (LINDGREN 1952) This phenomenon is due to compression of the cord



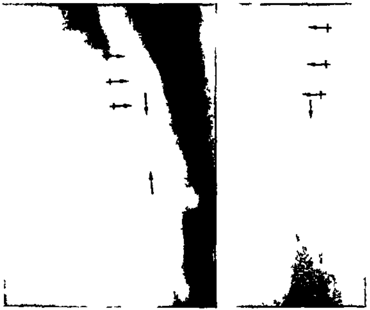
Fig. 6. The air from the spinal space enters chiefly the ventricular system.



Fig. 7. Intramedullary astrocytoma. Massive thickening of cord, markedly widened cisterna magna.

from the side with resultant increase in its sagittal diameter. The true state of affairs will be evident in a tomographic cut through the tumor (Fig. 8a) as well as in the sagittal view (Fig. 8b). It is worth mentioning that even in cases in which the tomographic cut is not strictly median the outlines of the cord may still be distinctly identified. Positioning of the subject so that the spine is absolutely parallel to the plane of the table is, of course, not always possible.

The dorsal subarachnoid space in the thoracic region is much less frequently filled than the ventral subarachnoid space, for a reason which is not at once apparent. The influence of gravity upon the position of the cord within the spinal canal is recognized (LINDGREN, and JIROUT). Nevertheless, in pneumomyelograms published in the literature, and obtained by lumbar puncture with the subject prone, i.e. in the position apparently the most favourable for optimal gas filling of the subarachnoid space, it is often again only the ventral space that is demonstrated (BONTE, DELLOSSI and CICHETTI). We have the impression that the factor of primary importance is the degree of curvature of the spine. In our material the dorsal subarachnoid space was properly air filled only in cases with more or less marked dorsal hyperkyphosis (Fig. 9), and this is also evident in a number of gas myelograms, published, for instance, by JACOBSEN & HYLLESTED (1958) and by BONTE et coll. With increasing hyperlordosis, a ventral trend of the cord occurs, resulting in unfolding of the dorsal subarachnoid space, as first reported by LINDGREN (1941).



a b

Fig 8 a) Meningioma at T[illegible] (→) situated mostly to the left b) Arrows (↔) indicate the cord

Another factor playing probably a certain role in this problem is exemplified by sporadic cases in which an unusually large quantity of fluid (75 ml and over) has been evacuated, and in which the cord is more or less thinned and atrophied and the dorsal subarachnoid space well filled with air Such a case was one of a man of 54 suffering from slowly progressing lower spastic paraparesis (Fig 9a) Similar although not such marked signs were evident in a case of a middle aged woman with syringomyelia in which 53 ml of fluid were evacuated and in which a fusiform thickening of the cord at the cervicothoracic junction, and a slight thinning of the dorsal part of the cord were demonstrated As an incidental finding a slight protrusion of the T8—9 disk was outlined with air The size of the spinal canal in these cases is not increased and the large amount of cerebrospinal fluid and the good air filling of the dorsal subarachnoid space may be explained by the atrophy of the cord possibly due to external hydrocephalus similar to the external hydrocephalus that occurs in atrophy of the brain

Schaltenbrand (1949) advanced the theory that the dorsal subarachnoid space is separated from the ventral space and reserved for the downward flow of the CSF whilst the latter serves for the upwards directed flow This could perhaps explain the difference in the air filling of the ventral and dorsal spinal subarachnoid spaces

Negative contrast myelography is particularly satisfactory in the lumbar



Fig 9 a) Diffuse atrophy of cord in hyperkyphosis b) Syringomyelia thickening of cord at cerv thoracic junction hyperkyphosis Slight protrusion (arrow) of T8—9 disk

region as was the case in an obese female subject with complete obstruction at the level of I 1 caused by a neurofibroma Some 35 ml of air were injected and found sufficient for clearly outlining the lesion

Dorsal contours of the intervertebral disks are well outlined with a negative contrast medium so that all stages of disk lesions from a simple protrusion (cf Fig 13) to fully developed herniation (cf Fig 15a) may be demonstrated The well known limits of myelographic diagnosis in disk lesions, set in the main by the physiologically greater width of the epidural space at the level of the two lowermost lumbar disks the herniation of which may thus escape detection, are equally valid for both positive and negative contrast media The cutting off of the neural sheaths a frequent although not altogether dependable sign in positive myelography is naturally impossible to observe with a negative



Fig 10 Neural sheaths in gas contrast (on left side of sac)



Fig 11 Lumbar intumescence in a child (a) and adult (b)

medium Air filled normal sheaths may however be identified in isolated cases (Fig 10)

The lumbar intumescence is of considerable pneumographic importance and is evidenced by a thickening of the cord usually towards the ventral wall of the dural sac it may vary in shape from a club to a hockey stick and stands out clearly in children (Fig 11a) The shape usually causes a reversal of the air distribution the ventral subarachnoid space fades progressively out while the dorsal space fills with gas Narrowing of the ventral subarachnoid space at the level of the lumbar intumescence may suggest a pathologic bul[illegible] in the ventral outline of the cord (Fig 11b) although such an interpretation must be made with some caution



Fig 12 Filaments of the cauda



Fig 13 Individual root directed towards intervertebral foramen intimate relationship to the protruding L3—4 disk (arrow)

The filaments of the cauda are usually satisfactorily demonstrated with a negative contrast medium as they run roughly parallel to the walls of the spinal canal (Fig 12) Individual roots have been repeatedly demonstrated in their relation to a protruding disk in tomograms (Fig 13) The lumbar sac may however be devoid of filaments whereas in anatomic specimens the sac is for the greater part filled up with the cauda This difference is caused in the first place by the collapse of the membranous sac at autopsy and by the selective tomographic demonstration of only one layer, as well as infiltration of the cauda by gas with resultant masking of the individual filaments in the film Conventional films are probably preferable to tomograms for the pneumographic study of the cauda in its entirety

One of our cases was of particular interest The usual sensations were absent in the course of the insufflation, and although relatively large amounts of air were introduced a pressure of only 250 mm H_2O as shown by the intraspinal



a b

Fig 14 Accidental peridurography a) The spinal nerves in the intervertebral foramina appear as rounded densities b) Accumulation of air in the area of lumbar puncture (arrow) pneumomediastinum.

pressure curve could be reached No filling was evident but in the dorsocranial part of each intervertebral foramen a rounded opacity (Fig 14a) corresponding to the axial projection of the intervertebral nerve or of the spinal ganglion could be defined A sagittal view (Fig 14b) disclosed an accumulation of air in the region of the lumbar puncture and separation of the mediastinal pleura along the descending aorta No doubt the tip of the needle escaped from the dural sac so that insufflation into the epidural space took place with resultant pneumomediastinum and the outlining of the intervertebral structures with air This may be described as accidental peridurography

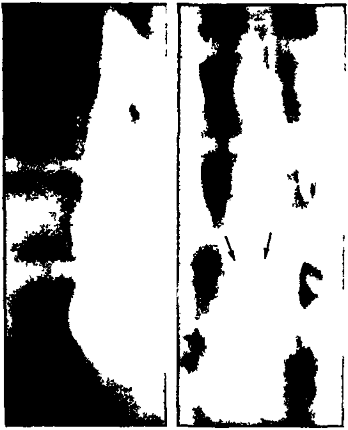


Fig 15 Left Widening of the spinal canal between L2 and S1 with deep excavations of the vertebral bodies Disk hernia L2—3 reaching medulla *Right* Domelike defect at L4 (Operation Intradural lipoma)



Fig 16 Diastematomyelia Division of the cord into two asymmetric portions separated by a bony spur

Congenital anomalies of the intraspinal structures may be investigated in detail by negative contrast myelography Conventional roentgenography in a case of a boy of 17 years, who since birth had had slight lower paraparesis and mild disturbances of micturition, revealed enormous widening of the spinal canal from L2 to S1 with deep excavations of the dorsal aspects of the vertebral bodies A dome like defect in the air column outlining the widened canal was demonstrated by gas myelography (Fig 15) The band like outline visible in the free portion of the lumbar canal presumably corresponds to an abnormally low reaching cord At operation, an inoperable intradural lipoma diffusely infiltrating the cauda was found

Roentgenograms in a case of a 8 year old boy with right club foot and slight thoracolumbar hypertrichosis showed widening of the lumbo sacral spinal canal, fusion of the vertebral bodies and a bony spur at the level of T12—L1 characteristic of a diastematomyelia Negative contrast myelography (Fig 16) revealed the typical longitudinal division of the spinal cord into two asym

metrical portions separated by a bony septum The pneumomyelographic appearances would appear to be more revealing and instructive than the appearances obtained from positive contrast media in this condition

The writer would like to state, in conclusion, that the primary purpose of this communication was to show the possibilities offered by negative contrast myelography carried out by means of ordinary equipment It would appear that this method particularly in conjunction with tomography is at least as dependable as positive contrast myelography

The procedure demonstrates the cord in its entirety as an anatomic structure and may thus yield information not otherwise obtainable It would appear to be the method of choice excepting in conditions such as arachnoiditis or spinal vascular anomalies in which opaque contrast myelography is probably to be preferred

SUMMARY

A technique of negative contrast myelography by the lumbar route performed by tomography on an ordinary couch is described The advantages of the method over positive contrast myelography are discussed

ZUSAMMENFASSUNG

Eine Methode der lumbalen negativen Kontrastmyelographie mit Hilfe von Schichtunter suchung auf einem gewöhnlichen Röntgentisch wird beschrieben Die Vorteile dieser Methode uber die positive Kontrastmyelographie werden erörtert

RÉSUMÉ

L auteur décrit une technique de myélographie à contraste négatif par voie lombaire réaliseé par tomographie sur une table ordinaire Il examine les avantages de cette méthode par rapport a la myélographie avec contraste positif

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THE SPEED AND CONTRAST OF DENTAL FILMS

by

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The film commonly used in dental roentgenology is of the no screen type There are numerous kinds on the market each with different characteristics The film employed in diagnostic work must be of a type that permits roentgenograms of good contrast and definition to be obtained with minimum radiation dosage to the patient

The purpose of this work was to investigate the speed and contrast of ten dental films by an analysis of their characteristic curves according to the American standard method for the sensitometry of medical roentgen films, A S A PH 2 9 1956 Comparison of speed and contrast was also made with various developers and different filtration of the incident radiation

The characteristic curve of a film is a graphic representation of the density after development plotted against the exposure which is expressed as the radiation dose in r units given to the film, the density (D) after exposure and development is the $\log_{10}$ of the relationship of the intensity of the visible light before and after passage of the latter through the film

Films and development The following dental films were investigated Cea Normal Cea Rapid, Dupont S 1 Dupont D 1 Gevaert Dentus Rapid, I F I Ilford Contrast, Ilford Standard, Kodak Radia Tized and Kodak Ultra Speed These films were first developed by the A S A method and then according to the recommendations given by the manufacturers or when no recommenda

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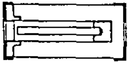


Fig 1 Double chamber Scale 1 1

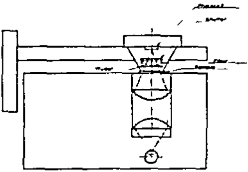


Fig 2 Baldwin transmission densitometer

tions were available with Rontogen developer (Tetenal Photowerk, Hamburg and Berlin)

The A S A developer had the following composition

Monomethyl para aminophenal sulfate (Metol)	2 2	gram
Sodium sulfite (desiccated)	72 0	»
Hydroquinone (1 4-dihydroxibenzene)	8 8	»
Sodium carbonate (monohydrate)	56 0	»
Potassium bromide	4 0	»
Distilled water	in an amount to produce 1 0	liter

Immediately following development the films were immersed for 30 seconds in a stop bath consisting of 1 to 2 per cent acetic acid at a temperature of about 20 C The films were then placed for 8 minutes in a fixing bath consisting of

Sodium thiosulfate anhydrous	225 0	gram
Sodium acetate anhydrous	30 0	»
Boric acid crystals	10 0	»
Sodium bisulfite	10 0	»
Aluminum potassium sulfate (alum)	30 0	»
Distilled water	in an amount to produce 1 0	liter

The 'special developers used were

Film	*Special developer*
Cea	Rontogen
Dupont	Rontogen
Gevaert	G 150 (Gevaert)
IFI	Rontogen
Ilford	Ilford dental X ray developer
Kodak	Kodak dental X ray developer

Roentgen apparatus The investigations were carried out with a Philips Stand ard DLX roentgen apparatus with a Rotalix double focus tube A magnetic filament current stabilizer held the current constant at ± 0 5 per cent and the true voltage was regulated before every exposure

The recommendations given by the A S A in the American standard method for the sensitometry of medical roentgen films (PH 2 9 1956) were followed in the first part of the investigation The roentgen radiation used for the sensitometric exposure of dental films shall have a quality equivalent to a half value layer of 2 mm Al Radiation of this quality shall be obtained from a roentgen tube provided with an aluminium filter such that the sum of the inherent filtration of the tube and the added aluminium filtration is equivalent to 2 5 mm of aluminium The tube potential shall be adjusted to produce radiation of specified quality under the above conditions

Exposure technique Exposures were made at focus film distances of 148 cm and 100 cm The films were placed on an iron plate, the field size of which was approximately 120 cm² The radiation dosage was measured by ionization chambers placed in the centre of the iron plate Iron was selected because at the radiation energy levels used, it produces less secondary radiation than other materials (LORENTZON 1954, WALSTAM 1954, MATTSSON 1956) Black paper and thin lead foil are packed behind the roentgen films in the film packets Backscatter from the lead foil, as characteristic L- and M radiation with photon energy of 15 to 3 keV, photoelectrons and Auger electrons was mostly attenuated by the black paper and the film received no measurable exposure (MANSON HING 1959)

Measurement of dosage The doses to the films were determined with double chambers of the type described by SIEVERT & WALSTAM 1951, SIEVERT 1957 and LARSSON 1958 Such a double chamber consists of three concentric tubes of graphitized paper insulated from each other by polystyrene and forming two ionization chambers, one inside the other The dimensions of the chambers are so adjusted that the outer is about ten times more sensitive than the inner chamber The double chamber is kept in a plastic container during measure ments The chambers were charged either to 30 V or 150 V With these poten tials the following dose ranges were covered

Potential	Outer chamber	Inner chamber
30 V	5 mr— 50 mr	50 mr— 500 mr
150 V	20 mr—200 mr	200 mr—2 500 mr

The mean value from the same four chambers was used for every measure ment Eight measurements of the dose at 9 mAs and at the same place in the field made over a period of two years showed maximum variations of ± 3

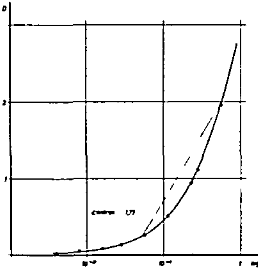


Fig 3 Characteristic curve in accordance with A S.A sensitometric method Kodak Radia Tized

per cent the dose at the same site in the field at 90 mAs or 10 × 9 mAs was almost precisely ten times larger

The chambers were compared with a Victoreen chamber at the Institute of Radiophysics at Karolinska Sjukhuset (LORENTZON) The calibration factors were valid at 20 C and a pressure of 76 cm Hg varying pressure has been taken into consideration, but varying temperature has been neglected No correction for the angle of incidence was necessary because the radiation struck the chambers perpendicularly It is reasonable to assume that the doses measured in the investigation as compared with the calibration chamber fall within the limits of a maximum error of ± 5 per cent

Dose variations at different parts of the field with the same exposure were measured The maximal dose variations within the square of 120 cm used in the film exposures were ± 3 per cent compared with the dose at the centre of the radiation field The doses given to the films may thus have a maximum variation of ± 8 per cent

A narrow beam was used for measurement of the half value layer The focus filter and filter chamber distances were the same namely 50 cm At a voltage of 60 kV and with a total filtration equivalent to 2 5 mm of aluminium the half value layer was approximately 2 mm of aluminium (between 1 9 and 2 mm Al) No significant change of half value layer was found if the field size was 120 cm²

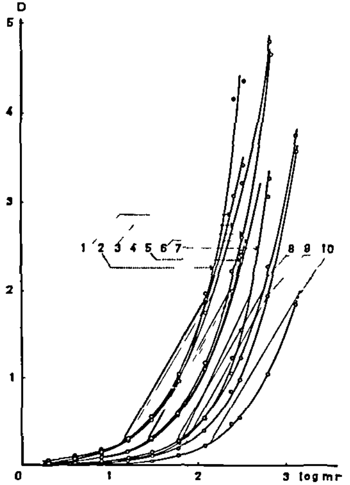


Fig 4 Characteristic curves of ten dental films according to the A S A sensitometric method (27/10 59)

1 Kodak Ultra Speed
2 Ilford Standard
3 Cea Rapid
4 I F I
5 Gevaert Dentus Rapid
6 Cea Normal
7 Ilford Contrast
8 Kodak Radia Tized
9 Dupont D I
10 Dupont S I

Film treatment The Schwarzschild factor is 1 at the photon energy used Films with the same emulsion number were given graduated series of exposures with doses from 2 mr up to 1 180 mr in order to produce characteristic curves, in film packets with two films only the one lying nearer the tube was developed Temperature and concentration were equalised throughout the developer during processing by intermittent agitation Twelve liters of fresh developer were used for every 100 films (12 dm^2) A thermostat kept the development temperature constant at 20 0° C $\pm$ 0 2 C

The developing process was stopped in 1 5 per cent acetic acid and the films were fixed for 8 minutes The film density was determined with a Baldwin Transmission Densitometer which is in accordance with 'American Standard Diffuse Transmission Density (Z 38,25—1946) (Fig 2)

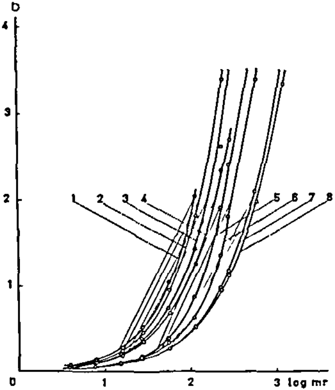


Fig 5 Characteristic curves of four film types developed according to A S A and according to the recommendations given by the film manufacturers

Film	Developer
1 Ilford Standard	Ilford Dental X ray developer
2 Ilford Standard	A S.A
3 Gevaert Dentus Rapid	G 150
4 Gevaert Dentus Rapid	A S.A
5 Ilford Contrast	Ilford dental X ray developer
6 Ilford Contrast	A S A
7 Kodak Radia Tized	Kodak dental X ray developer
8 Kodak Rad a Tized	A S A

Results

The speed of the films was determined in accordance with A S A (PH 2 9 1956) Every batch of films was given a number of exposures to result in a series of densities above base and fog ranging from approximately 0 20 to 3 0 in a suitable number of increments These densities have been plotted against the logarithm of the exposure (Figs 3 4 5) The exposure required to produce a density of 1 0 above the base and fog density has been determined from this curve The speed of the film was calculated as the reciprocal of this exposure measured in roentgens

Table 1

Emulsion numbers of the films investigated

Gea Normal	70735	81001	—	81003
Gea Rapid	80762	71002	—	71005
Dupont S 1	—	551 270 2	—	551 285 1
Dupont D 1	—	550-405 7	—	550 450 7
Gevaert Dentus Rapid	2440197	341	—	2454109
IFI	25118	25118	—	26579
Ilford Contrast	705 R	705 R	—	751
Ilford Standard	4NF677C	691	—	691
Kodak Radia Tized	03105029484	03105049521	03105049521	03116189444
Kodak Ultraspeed	02242057456	02242057456	—	02278037545

The emulsion number of the films used is shown in Table 1 In Table 2 are recorded the speed of the films at four different times, the density of fog above base, and the remaining recommended shelf life in months The density of fog is measured above the base, where the light absorption also is caused by the light absorption of the unexposed emulsion after fixing The speed of the same film varied within $\pm$ 10 per cent with different emulsions The film speed was lower with the use of the developer recommended by A S A than when the special developers recommended by the film manufacturers, were employed (see Table 3 and Fig 5)

The dental films investigated exhibit very different speeds These vary from between 1 8 and 19, and the film types may be divided into three groups, those of high, medium and low speed (Table 4)

The contrast of the dental films was determined as the average gradient, this is defined as the slope of a straight line drawn on the density log exposure curve between the points on the curve at densities of 0 25 and 2 00 above the base and fog density

$$\text{Average gradient} = \frac{1\ 75}{\log E_2 - \log E_1}$$

where E_2 is the exposure corresponding to a density of 2 00 above base and fog and E_1 is the exposure corresponding to a density of 0 25 above base and fog density

The contrast of the films was 1 7 to 1 9 in all cases with the exception of Ilford Contrast which gave a contrast of 2 0 to 2 1 (Table 2 and Fig 4)

The film contrast tends to increase with 'special developers (Table 3) The shapes of the characteristic curves shown in Figs 4 and 5 are almost the same for all films except Ilford Contrast

Investigation with phantom The various types of roentgen apparatus used in dental roentgenology have different voltage and filtration characteristics Radiation of a half value layer of 2 mm aluminium has been recommended by BJARNGARD HOLLENDER, LINDAHL & SONESSON (1960) The quality of the radiation is, however, altered after filtration through an object and a phantom was used to evaluate the change in quality The phantom consisted of bone salt, polythene, and water According to BEST & TAYLOR (1955) compact bone consists of 25 per cent water, 45 per cent inorganic substances and 30 per cent organic material The inorganic contribution is approx a mixture of $Ca_3(PO_4)_2$ and $CaCO_3$, and most analyses show that these two components are mixed in the ratio of 39 6 To facilitate handling these chemicals were mixed with polythene, the mixture was then baked and the plastic mass rolled out into sheets, 2 mm thick Polythene has approximately the same atomic composition, as far as radiation is concerned, as organic structure or water (NELSON 1949) Some plates of polythene and bone salt contained 45 per cent by weight inorganic substance and 55 per cent polythene These plates were approximately equivalent to compact bone, other plates contained 11 25 per cent bone salt and 88 75 per cent polythene and could be assumed to be equivalent to cancellous bone

The phantom was composed of 50 mm water, 4 mm 'compact bone plates 8 mm cancellous bone plates, 4 mm 'compact bone plates, and 1 mm polythene the latter formed the bottom of the plastic tank (Fig 6)

The distance from the focus to the ionisation chamber described above or to the film was 100 cm during the experiments with this phantom The distance from the bottom of the phantom to the longitudinal axis of the chamber was 20 mm Secondary radiation from outer parts of the radiated phantom may strike the chamber at an angle According to SIEVERT & WALSTAM the angular dependence of the chamber may be neglected in the case of such angles and this has been done in this investigation (see Fig 6) The wavelength dependence of the chamber is according to the same authors less than 5 per cent when radiation of a half value layer of 2 to 5 mm Al is used According to LARSSON (1958) this wavelength dependence is approximately 2 per cent The radiation intensity transmitted through the phantom was halved by 4 7 mm Al

Results with the phantom The speed of the film increased by 13 per cent when the radiation quality was altered by transmission through the phantom, although the contrast remained the same In Table 5 and Fig 7 the speed and contrast of Kodak Radia Tized film exposed with 2 mm Al half value layer radiation are compared with the speed and contrast with radiation transmitted through the phantom The voltage of the tube and the roentgen apparatus filtration were the same in each case

Table 2

Speed contrast fog (above base) of ten dental films measured according to the A.S A method for the $\frac{1\ 75}{\log E_2 - \log L_1}$ *where* Γ_2 *is the exposure giving a density of 2 0 above base and fog and* E_1 *is the exposure tion also is caused by the light absorption of the emulsion after fixing*

	June 1959				October 1959	
	Speed	Contrast	Fog (above base)	Remaining time in months	Speed	Contrast
Kodak Ultraspeed	19	1 7	0 12	8	18	1 7
Ilford Standard	—	—	—	—	17	1 8
Cea Rapid	17	1 7	0 08	—	17	1 7
IFI	11 5	1 9	0 10	7	10	1 9
Gevaert Dentus Rapid	12	1 9	0 16	2	10	1 8
Cea Normal	8 3	1 9	0 06	16	9 1	1 8
Ilford Contrast	4 7	2 0	0 04	—	4 8	2 1
Kodak Radia Tized	—	—	—	—	4 4	1 8
Dupont D 1	—	—	—	—	3 5	1 9
Dupont S 1	—	—	—	—	1 8	1 8

Table 3

Comparison of speed contrast and fog using the developer according to A S A and some special developers

Developer	Time	Temp
A. S A	4 1/2 min	20 C
Rontogen	5 »	»
Gevaert G 150	5 »	»
Ilford Dental Developer	5 »	»
Kodak Dental Developer	4 1/2 »	»

	A S A developer			
	Speed	Contrast	Fog above base	Remaining time in months
Cea Normal	8 7	1 8	0 13	12
Cea Rapid	24	1 9	0 06	9
Dupont S-1	1 9	1 8	0 01	7
Dupont D 1	3 6	1 9	0 02	11
Gevaert Dentus Rapid	11 5	1 8	0 07	4
IFI	10	1 8	0 04	7
Ilford Contrast	5 8	2 1	0 03	—
Ilford Standard	16 6	2 0	0 22	—
Kodak Radia Tized	4 0	1 7	0 05	4
Kodak Ultraspeed	21	1 8	0 13	10

Table 2 *(cont.)*

sensitometry of medical X ray films The speed is $\frac{1}{r}$ where r is the film dose giving density 1 0 Contrast is giving a density of 0 25 above base and fog The fog is measured above the base where the light absorp-

		January 1960				September 1960			
Fog (above base)	Remaining time in months	Speed	Contrast	Fog (above base)	Remaining time in months	Speed	Contrast	Fog (above base)	Remaining time in months
0 17	4					21	1 8	0 13	10
0 13	—					17	2 0	0.22	—
0 06	—					24	1 9	0 06	9
0 13	3					10	1 8	0 04	7
0 12	2					12	1 8	0 07	4
0 04	9					8 7	1 8	0 13	12
0 03	—					5 8	2 1	0 03	—
0 04	8	4 3	1 8	0 06	5	4 0	1 7	0 05	4
0 01	7					3 6	1 9	0 01	11
0 01	8					1 9	1 8	0 02	7

Table 3 *(cont.)*

recommended by the film manufacturers or for some films Rontogen developer

Special developer				
Speed	Contrast	Fog above base	Remaining time in months	
8 7	1 8	0 13	12	Rontogen
24	2 0	0 06	9	Rontogen
2 0	1 7	0 01	7	Rontogen
3.5	1 9	0 01	11	Rontogen
13 4	1 9	0 10	4	G 150
10	1 9	0 05	7	Rontogen
7 8	2.2	0 04	—	Ilford Dental X ray developer
18.2	2 0	0 21	—	Ilford Dental X ray developer
4 4	1 8	0 05	4	Kodak Dental X ray developer
22	1 8	0 12	10	Kodak Dental X ray developer

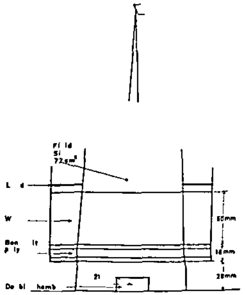


Fig 6 Experimental arrangement for measuring the dose of the radiation filtered in the phantom used

Table 4

Film	Speed	Group
Kodak Ultraspeed	19	High speed
Cea Rapid	19	High speed
Ilford Standard	17	High speed
Gevaert Dentus Rapid	11	Medium speed
IFI	10 5	Medium speed
Cea Normal	9	Medium speed
Ilford Contrast	5	Low speed
Kodak Radia Tized	4 3	Low speed
Dupont D 1	3 5	Low speed
Dupont S 1	1 8	Low speed

Table 5

The speed and contrast of Kodak Radia Tized at two different filtrations of the radiation (1) in accordance with A S A and (2) when the radiation is further filtered in a phantom

	Speed	Contrast
7 January 1960		
2 mm Al HVL	4 3	1 8
4 7 mm Al HVL	5 5	1 8
23 January 1960		
2 mm Al HVL	4 3	1 7
4 7 mm Al HVL	5 7	1 8

Discussion

Film speed The maximum variation of the doses was as stated ± 8 % Another variation, that of development, is more difficult to estimate However, when three series of 10 films (Kodak Radia Tized) were exposed in the same region of the field, at different mAs, and developed before during, and after the development of the other 9 film series the maximum density variations

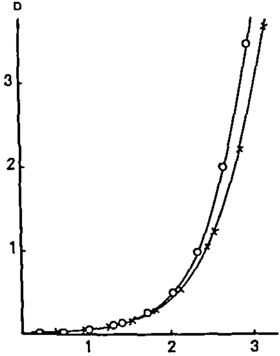


Fig 7

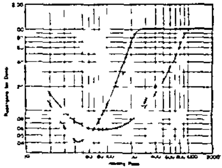


Fig 8 Roentgens for a density of 1 0 as a function of roentgen tube voltage for light and heavy filtration on Kodak Blue Brand Medical X ray film (Wilsey)

Fig 7 Two characteristic curves of Kodak Radia Tized Flm the curve to the right in accordance with ASA and that to the left when the incident radiation has been filtered in a phantom

within the three series were ± 0 01 This is the density measurement error and hows that the same developer will produce very uniform development

The speed of different emulsions of the same sort of film varied by ± 10 per cent with the exception of Cea Rapid These variations may depend on variations of the doses or on the development but probably also on the different speeds of different emulsions in clinical work however, this variation in emulsion speed is of little consequence

The film speed increases when the special developer recommended by the film manufacturer is used in place of that recommended by ASA This is the case for all films investigated No increase of speed was obtained by the use of Rontogen developer When comparing the developers, the same film emul sions were used for both types of developer and the films were exposed at the same site in the field The variations of the corresponding doses were consequently very small and accordingly the different speeds depended on the development The temperature was 20 C but the development time varied according to the manufacturers recommendations thus for ASA and Kodak developers a period of 4 1/2 minutes and for the other developers of 5 minutes were used It is therefore obvious that the special types of developers may be recommended for clinical use especially as the fog will be almost the same for the ASA developer as for the special developers

The filtration of the radiation will correspond approximately to the filtration of a dental object when radiation is transmitted through a phantom as described above The spectral distribution is thus altered for the radiation is harder, the speed of dental film (Kodak Radia Tized) is increased about 20 per cent by such harder radiation This is in agreement with the conclusions reached by WILSEY (1951), who used different roentgen tube voltages and light and heavy filtration WILSEY showed that at 60 kV Kodak Blue Brand medical film needs 0 06 r for a density of 1 0 with light filtration (total filtration of 1 5 mm aluminium) and 0 05 r for a density of 1 0 with heavy filtration (total filtration of 1 5 mm aluminium and 1 0 mm Cu) (Fig 8) WILSEY also stated that the film speed does not vary by more than 10 per cent for lightly filtered radiation in the range 60 to 140 kV When radiation at 60 kV with heavy filtration is used to blacken the film, a greater part of the radiation has a photon energy that may possibly correspond to the critical absorption limits of silver and bromine than is the case when radiation with light filtration is used The radiation exposing dental films will not be more heavily filtered by the object than by 1 5 mm Al and 1 0 mm Cu and not less than 1 5 mm Al If dental films correspond approximately to the film used by WILSEY, their speed is highest at 40 to 60 kV

According to MANSON HING (1959), lightly filtered (2 mm Al equivalent) radiation at 60 kV will give the highest film speed of two very fast dental films A heavier filtration would perhaps give another result as suggested by WILSEY The spectral shape of the very lightly filtered radiation at 90 kV and 50 kV is given by HETTINGER & STARFELT (1958) (Fig 9) The portion of the radiation with lower energy than the silver K edge (25 5 keV) is large at 50 kV and is not negligible even at 90 kV According to SEEMAN (1950) the no screen emulsions investigated have the highest sensitivity for a given roentgen dose when the energy of the mono energetic radiation is little more than 25 5 keV Broadly speaking it is probable that radiation from a tube running at about 40 to 60 kV and filtered in a dental object will produce the highest speed in dental films

Film contrast All the films investigated have a contrast (average gradient) of 1 7 to 1 9 except Ilford Contrast in which the contrast is 2 1 to 2 2 The contrast of different emulsions of the same sort of film varies within $\pm$ 5 per cent It would be difficult in clinical work to discern a variation of contrast up to 10 per cent although the higher contrast of Ilford Contrast film should be evident It is interesting to note that this film of high contrast lies in the low speed group Some hypothetic characteristic curves for fast, intermediate and slow speed films given by PAFFENBERGER, FORZIATI & KUMPULA (1959) indicate that the faster the film, the higher the contrast (the average gradient) This is not in agreement with the present findings

The exposure latitude must be the same for all films investigated, with exception of Ilford Contrast, because the contrast is the same Most dental

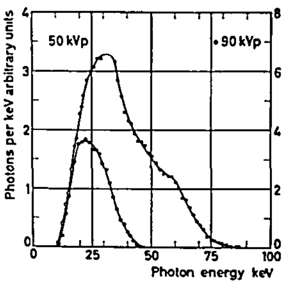


Fig 9 The spectral shape of the radiation from a tube running at 90 kV 150 mA and 50 kV 69 mA (Hettinger Starfelt)

roentgen apparatus are not however fitted with a radiation intensity (mA) control and the timer is the only means of varying the exposure at a given kilovoltage When using fast films even small variations in time will give high percentage variations and thus produce undesirable over exposure or under exposure Fast film speeds necessitate an electrically actuated timer graduated in small fractions of a second

The varying amounts of radiation striking different parts of the film in clinical roentgenography depend on the different absorption properties of parts of the object for the quality of incident radiation The relative dosage of the different parts of the film is consequently independent of the exposure time The relative density of these parts after processing is, however dependent on the exposure time as is evident from the characteristic curves The density differences i e the contrast, are higher the more exposed the film has been up to the limit of total over exposure This limit apparently depends on the light intensity of the viewing box ordinary viewing boxes allow densities of up to about 2 5

SUMMARY

The speeds of ten dental films were investigated according to the American standard method for the sensitometry of medical roentgen films The speeds increased when the developer recommended by the film manufacturer was used or when heavier filtration of the radiation than that suggested by the A S A was employed The contrast of the films with the exception of Ilford Contrast film was almost the same

ZUSAMMENFASSUNG

Zehn Zahnfilme verschiedenes Ursprungs wurden nach der amerikanischen Standard methode sensitometrisch auf ihre Geschwindigkeit geprüft Die Geschwindigkeit aller Filme war am besten wenn den vom Hersteller empfohlenen Entwickler benutzt wurde oder wenn stärkere Filter als in der amerikanischen Standardmethode vorgesehen benutzt wurden Der Kontrast aller Filme war ziemlich gleich mit der Ausnahme des Ilford Kontrast Filme

RÉSUMÉ

La rapidité de dix films dentaires a été étudiée par la méthode d étalonnage americaine de sensitométrie des films radiologiques médicaux La rapidité augmente quand on utilise le révelateur recommandé par le fabricant de films et quand on emploie une filtration plus forte que celle qui est proposee par l A S A A l exception du film Contrast Ilford le contraste des films est resté presque inchange

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VI SYMPOSIUM NEURORADIOLOGICUM ROMA

18—22 September 1961

PART I

The contributions to the previous symposia, excepting those to the first one in 1939, have been published in Acta Radiologica We now have the privilege to publish the majority of the papers presented at the 6th Symposium Neuroradiologicum in Rome A few of the papers read at the symposium have not been submitted for publication, the titles of these are included in the table of contents together with such information as may have been procured

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RUGGIERO G CALABRO A METZGER J and SIMON J Paris	Arteriography of the external carotid artery
SCATLIFF J and GREENSPAN R New Haven	Radiographic evaluation of major arteries of the neck by intravenous aortography
SCHECHTER M New York	Percutaneous carotid catheterization
SCHECHTER M and ELKIN M New York	Layering effect in cerebral angiography

It has been the rule for the contributions in these special issues of Acta Radiologica not to be subjected to editorial revision to such an extent as are articles accepted for publication in our regular numbers. It is a matter of regret that perhaps not all the contributions in this issue from a scientific standpoint correspond to the standard we endeavour to maintain. The papers presented have been arranged in alphabetical order within adequate subject divisions. The titles are in the same language as the subject matter irrespective of the language in which they appeared in the program; the wording of some of the titles have also in some instances been slightly altered.

The Editor

ALLOCUZIONE PRESIDENZIALE

Professor McRAE

Signori ex presidenti dei Symposia,

Egregi Colleghi

Signore e Signori

Ogni 20—30 anni il nome di un medico e associato ad una scoperta o ad altro avvenimento suscettibile di sconvolgere l ordinamento della Medicina Ma al di fuori di questi destini eccezionali nella carriera normale di un medico la posizione che io occupo in questo momento e senza dubbio fra le piu onorifiche ed io spero di rendermene completamente degno attraverso la continuazione del mio lavoro

Voi mi perdonerete dunque se io approfitto di questa occasione per fare innanzitutto una cosa che mi sta particolarmente a cuore ringraziare pubblicamente coloro che sono stati alla base del mio successo La strada della disciplina neurologica mi fu aperta dal mio Maestro, Prof Pasquale Penta Il Prof Mario Gozzano, che lo sostitui poi, incoraggio la mia inclinazione per la neuroradiologia conservandomi in seguito durante gli anni della mia permanenza all estero un appoggio disinteressato e leale Il mio Maestro ed amico Prof Castellano mi dimostro anche con l esempio quanto indispensabile sia per un neuroradiologo la conoscenza teorica della neurochirurgia Alla generosita spregiudicata del mio amico Prof Fabio Columella io debbo la gioia di poter lavorare di nuovo nel mio Paese

Ma la mia carriera e essenzialmente il risultato dell incontro fatto da me con due uomini l uno e svedese l altro e francese

Sono certo che non me ne vorrete se mi rivolgo ora a loro molto brevemente nella loro lingua Del resto parlare svedese col Prof Lindgren e in qualche modo ammettere lo svede e tra le lingue ufficiali di questo Symposium cio che in un Congresso Internazionale di Neuroradiologia e cosa naturale

Professor Lindgren. När jag för tretton år sedan för första gången kom till Ert land, hade jag ett intryck av att det var kallt, avlägset och nästan onaturligt för min latinska själ. Men jag stannade kvar där, därför att jag hade en bestämd känsla av att i Er ha mött, i en och samma person, en människa och doktor utan fruktan och tadel. Snart var vintern glömd, och jag lärde känna den svenska våren och Ni vet hur mycket jag nu älskar Ert land. Naturligtvis lärde jag mig i Stockholm det viktigaste av vad jag nu vet om neuroradiologi men jag tror i dag, efter så många år, att det största som jag har Er att tacka för är att jag kanske har fått något av Er outtröttliga strävan efter sanning både på medicinens och vetenskapens fält, en strävan som senare ständigt varit vägledande i mitt arbete.

Si j'ai appris la neuroradiologie en Suède, c'est à Paris et dans votre service, Monsieur DAVID, que j'ai pu faire le neuroradiologiste. A une époque où il n'était permis même pas l'espoir que nous avons aujourd'hui de voir un jour les médecins trouver leur place dans le monde privilégié du marché commun à côté du courrier et de quelques paires des chaussures, votre hospitalité m'avait donné une position unique. Je crois avoir été le premier médecin à plein temps en France. Votre confiance n'a pas connu de limites. Vous m'avez permis de m'épanouir en me donnant une assistance morale et matérielle sans réserve et vous l'avez étendue aux élèves que j'ai appelés d'Italie et à ceux qui sont venus me voir d'autres pays. Je suis sûr qu'à ma gratitude est associée celle de tous les neuroradiologistes latins car, à ma connaissance, vous avez été le premier neurochirurgien qui ait publiquement reconnu l'importance de la neuroradiologie et son droit à l'indépendance.

Merci encore, de tout mon cœur.

Il Dr McRae ha ricordato la storia dei symposia neuroradiologici. Essi sono stati la vera scuola della moderna neuroradiologia. Per parte mia io ho desiderato che, in occasione del Symposium di Roma, questa scuola fosse aperta al più gran numero di neuroradiologi, soprattutto di giovani neuroradiologi. Per questa ragione, siamo andati a cercarli un po' dappertutto nel mondo, predicando la causa della neuroradiologia. Il risultato è stato un gran numero d'iscritti e una grande affluenza di comunicazioni, molte delle quali ci saranne presentate da colleghi venuti da molto lontano. E mi sembra fin d'ora un risultato positivo poiché io ritengo che la scuola è più viva e più benefica quanto maggiore è lo scambio tra i più esperti e i più giovani. Questa larga adesione testimonia l'interesse per la nostra disciplina che non fa che espandersi e fornisce una inequivocabile dimostrazione del diritto di questa disciplina di essere in tutti i Paesi considerata al giusto rango, perché in tutti i Paesi siano forniti ai suoi cultori i mezzi materiali e sociali necessari per lavorare in pace e dignitosamente.

Essa infine fornisce la prova della validità dei principi che inspirano l'organizzazione dei Symposia Neuroradiologica: raduni indipendenti anticonformisti, liberi da quei legami equivoci che vanno sempre più corrompendo il clima della cosidetta diplomazia medica.

Nella sua allocuzione presidenziale al recente Congresso Internazionale di Neurologia il Prof. Gozzano rievocava i legami esistenti tra le varie discipline inerenti allo studio delle malattie del sistema nervoso. Io sottolineo questo legame che per lo meno per quanto concerne la neurologia, la neurochirurgia e la neuroradiologia deve essere il più stretto possibile così come intimi debbono essere i rapporti della Neuroradiologia con la Radiologia Generale. Ma dal posto in cui parlo e soprattutto nel Paese in qui parlo sento il dovere di esprimere senza esitazioni il mio fermo convincimento che in questa associazione la Neuroradiologia ha ormai diritto di assoluta parità.

Non mi resta ora che augurarmi che il nostro lavoro sia all'altezza della tradizione degli altri Symposia. Ed è con questa speranza che dichiaro aperto il VI *Symposium Neuroradiologicum*.

Giovanni Ruggiero

Presidential address

(Transcription into English of the main contents)

I am deeply sensible of the honour of presiding over this, the Sixth Symposium Neuroradiologicum, and would like to express the hope that my future contributions to our speciality may to some extent justify the trust that has been placed in me.

I am sure you will forgive me if I take advantage of this occasion first to express in public the debt I owe to my teachers without whom I should not be occupying this Chair today.

The way to the speciality of neuroradiology was opened to me by my first mentor, Professor Pasquale Penta. Professor Mario Gozzano who succeeded him encouraged my interest in neuroradiology and during my years of residence abroad gave me continuous support. My teacher and friend Professor Francesco Castellano by his example convinced me of the necessity of understanding the theoretical basis of neurosurgery. To the warm generosity and understanding of Professor Fabio Columella I owe the satisfaction of again being able to work in my own country.

The result of my encounter with two men, one Swedish, the other French, profoundly affected my career. I am sure I shall have your sympathetic understanding if I address myself briefly to each in his native tongue. In spite of the fact that Swedish is not one of the official languages of this symposium, it is

fitting that I should address my remarks to Professor Lindgren in that language in recognition of his own great work and of the other great contributions made by the Swedes to the science of neuroradiology

When I first came to your country thirteen years ago, Professor Lindgren, it appeared to be a cold, distant and almost strange land for a Latin like me I soon, however, experienced a thaw engendered by your kindness and obvious sincerity, and I was rooted in Sweden by the regard held by a pupil for a great physician I acquired in your country the essentials of my knowledge of neuroradiology, but today, after so many years, I believe that my greatest debt to you rests in the fact that I have perhaps acquired from you a little of your uncompromisingly clear thinking and scrupulous intellectual honesty which since the day I left you, has become the permanent objective of my work

If I learned neuroradiology in Sweden, it is in France and in your service, Monsieur David, that I became a neuroradiologist At the time I joined your department it was not even possible to hope — as it is today — that a physician in Europe could work and study as freely and easily in the different countries as has already become possible in the fields of exchange of commodities and labor under the Common Market I believe that through your influence I became the first full time hospital physician in France Your confidence in me knew no bounds You permitted me to develop through the unstinting support and material assistance that you extended to the pupils who came to me from Italy and from other countries I am sure that my gratitude is shared by all the Latin neuroradiologists, since to my knowledge you were the first neurosurgeon publicly to recognize the importance of neuroradiology and its right to independent status Thank you again with all my heart

Professor McRae has reviewed the history of the neuroradiological symposia They have formed the true school of modern neuroradiology I for my part wished on the occasion of the Symposium in Rome, that this school would be open to the greatest number of neuroradiologists, particularly our younger colleagues We searched the world and preached the cause of neuroradiology The result has been a large membership and a great number of contributions, many of which will be presented here by men from far away It seems that in this way the Congress has already produced positive results since I believe that the value of a school is measured by the amount of interchange between the experienced and the young and eager This broad union of minds and men testifies to the increasing interest in our subject and to its importance and right to full stature among other medical specialities This should result in the neuroradiologists in all countries being afforded the status and material means to work in peace and dignity

Finally this enthusiastic response demonstrates the validity of the principles that inspired the organisation of the neuroradiologic symposia independent non conformist meetings free from the progressively corrupting influence of so called medical diplomacy

Prof Gozzano in his presidential address at the recent International Congress of Neurology, pointed out the interdependence of the different specialities concerned in the study of the nervous system I would emphasize that this association should be as close as possible particularly as regards neurology, neurosurgery and neuroradiology and must be comparable to the link between neuroradiology and general radiology In my present position and above all in this country I feel bound to declare that neuroradiology has already justified its claim to full parity in this team of medical collaborants

It only remains to me to express the wish that our work will be worthy of the high standard set by previous symposia It is therefore with this aim that I declare open the Sixth Symposium Neuroradiologicum

Acknowledgements

The importance of the enthusiastic collaboration of my friend Professor Enzo Valentino is emphasized His work carried on with difficulty because of the great distance was indispensable to the success of this meeting Professor Valentino and I thank the members of the Committee of Honour the Italian Societies of Neurology, Radiology and Neurosurgery who have officially supported the Symposium, and particularly Professor Luigi Turano and Professor Alessandro Vallebona for their presence at the opening ceremony in their respective capacities of Director of the Institute of Radiology of the University of Rome and President of the S I R M N To Professor Turano goes my personal thanks for his moral support

Giovanni Ruggiero

FROM THE RADIOLOGIC DEPARTMENT (DIRECTORS E. DE FINE LICHT AND OLAF PETERSEN) AND THE OTOLOGIC DEPARTMENT (DIRECTOR N. RISKAER), COPENHAGEN COUNTY HOSPITAL, GENTOFTE, DENMARK

TOMOGRAPHY OF THE FACIAL CANAL IN NON-RHEUMATIC FACIAL PALSY

by

S. BRUNNER, O. PETERSEN and P. STOKSTED

The roentgenographic demonstration of the facial canal, or the intratemporal course of the facial nerve, has always been a difficult problem but one which has been considerably facilitated by tomography.

We use Massiot's tomograph (Polytome, SANS & PORCHER 1950) with the hypocycloid movement and perform the routine examinations in the frontal and lateral planes; experience has taught us that these projections are the best (BRUNNER, PETERSEN & STOKSTED 1961).

The course of the facial canal in the temporal bone is partly vertical and partly horizontal (Fig. 1). The horizontal part starts at the fundus of the internal auditory meatus and runs to the geniculate ganglion where, at its first bend, it passes just above the cochlea and medially to the ossicles; it then forms its second bend, from which the vertical part runs downwards to end in the stylomastoid foramen.

Technique. A frontal tomogram through the anterior part of the tympanic cavity (Fig. 2) demonstrates that the facial nerve enters the temporal bone at the fundus of the internal auditory meatus (6). A small portion of the facial canal can be seen above the cochlea (10). The malleus (m), lying more later

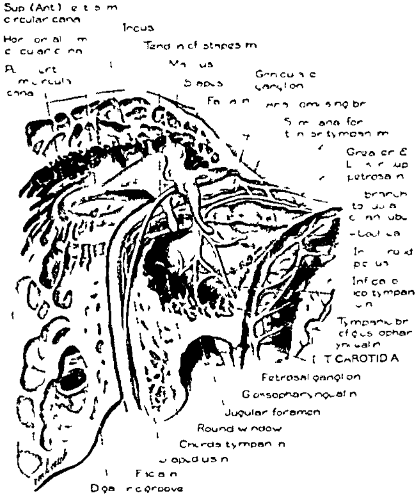


Fig 1 Course of the facial nerve in the temporal bone Courtesy of SHAMBOUGH Surgery of the ear Saunders Philadelphia 1959

ally is also outlined in this cut A section obtained more posteriorly (Fig 3) shows the vertical course of the canal as it runs down to the stylomastoid fora men (11) However, a lateral tomogram (Fig 4) through the medial part of the tympanic cavity (3), reveals the position of the facial canal from behind the tympanic cavity to its termination at the stylomastoid foramen, and is the more satisfactory for demonstrating the vertical part

The most common cause of non rheumatic peripheral facial palsy is chronic inflammation of the ear Primary and secondary growths as well as trauma may also produce this sequela

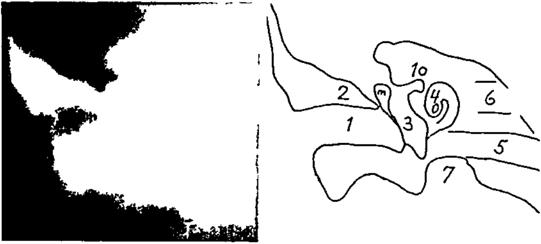


Fig 2 Frontal tomogram of the temporal bone at the level of the anterior part of the tympanic cavity External auditory meatus (1) spur (2) tympanic cavity (3) cochlea (4) pharyngeal tube (5) internal auditory meatus (6) fossa for the bulb of the jugular vein (7) horizontal part of facial canal (10) and malleus (m)

Case reports

Case 1 Woman aged 70 who from childhood had suffered from bilateral chronic inflammation of the middle ear with periodic suppuration Five months before admission the patient developed complete left facial palsy which was considered to be the result of cerebral haemorrhage Large central defects of the tympanic membranes were evident on both sides No discharge or sign of cholesteatoma The sense of taste was absent on the left anterior two-thirds of the tongue but the nasolacrimal reflexes were normal The audiogram disclosed reduced hearing of mixed conduction and perception type on both sides

Conventional roentgenography of the temporal bones revealed no evidence of destruction but frontal tomography (Fig 5) demonstrated a cavity in the anterior part of the tympanic cavity and involving the atticus This was combined with destruction of the supero-lateral region of the cochlea at the bends of the facial canal These findings were confirmed at operation at which a cholesteatoma in the anterior part of the antrum reaching down to the upper part of the tympanic cavity was also found

Case 2 Woman aged 59 with left incipient facial palsy which soon after admission became complete As a child she had suffered from left otitis media with reduced hearing on that side The ear had since been dry and the patient was otherwise well Nine days before admission she had pain followed by some discharge from the left ear The patient was treated with penicillin and paracentesis On otologic examination the left ear drum was red and swollen and there was considerable discharge No other changes were present

Frontal tomography (Fig 6) revealed that there were destructive changes in the region just above the cochlea near the second part of the facial canal The left antrum appeared to be slightly enlarged At operation osteitic changes with granulations and destruction in the region of the bends of the facial canal were evident The facial palsy gradually disappeared

Case 3 Woman aged 57 who had had radical mastectomy for carcinoma with hypophysectomy for osseous metastases Six months later she developed acute left peripheral facial

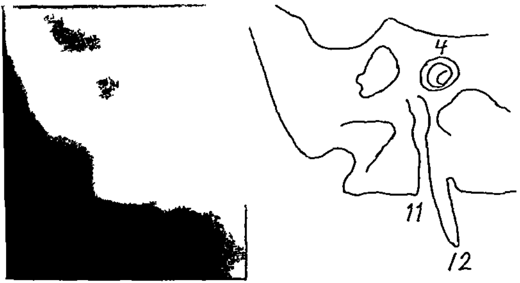


Fig 3 Frontal tomogram of temporal bone slightly posterior to the part shown in fig 2 Distal part of facial canal stylomastoid foramen (11) and styloid process (12)

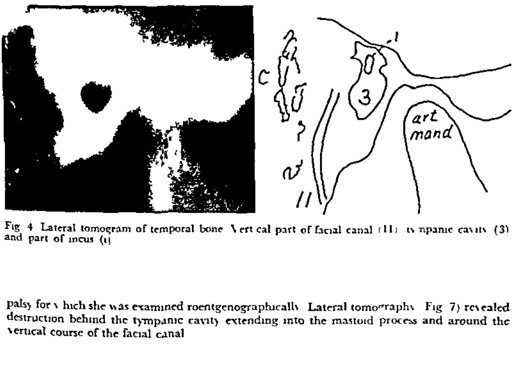


Fig 4 Lateral tomogram of temporal bone Vertical part of facial canal (11) tympanic cavity (3) and part of incus (1)

palsy for which she was examined roentgenographically Lateral tomography Fig 7) revealed destruction behind the tympanic cavity extending into the mastoid process and around the vertical course of the facial canal



Fig 5 Frontal tomogram of temporal bone (Case 1) Destruction of supero-lateral region of cochlea (4) and horizontal part of facial canal

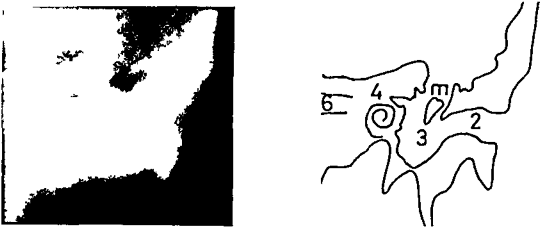


Fig 6 Frontal tomogram of temporal bone (Case 2) Destructive changes near second bend of facial canal

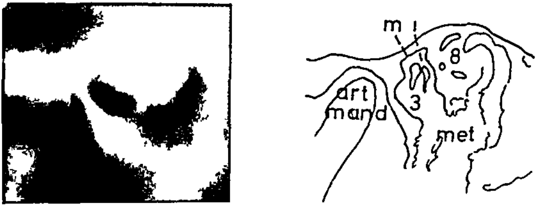


Fig 7 Lateral tomogram of temporal bone (Case 3) Metastatic destruction (met) in and around the vertical part of facial canal

SUMMARY

The tomographic examination of the temporal bone with special reference to cases of non rheumatic facial palsy is described

ZUSAMMENFASSUNG

Die Tomographie des Os temporale wird unter besondere Bezugnahme auf einige Falle mit Facialisparese nicht rheumatischer Genese beschrieben

RÉSUMÉ

Les auteurs decrivent l examen tomographique de l os temporal appliqué en particulier à des cas de paralysie faciale non rhumatismale (non a frigore)

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AUS DEM ANTHROPOLOGISCHEN INSTITUT (DIREKTOR PROF L BARTUCZ) DER L EOTVOS UNIVERSITAT UND DER HAUPTSTÄDTISCHEN GANZ MÁVAG POLIKLINIK (DIREKTOR J REGOS) DER STADT BUDAPEST, UNGARN

NEURORADIOLOGIE DER SCHADELNAHTE

von

BL BUGYI und I PINTÉR

Von den Schadelgebildern sind die Schadelnahte neuroradiologisch am wenigsten bearbeitet geworden Sie werden in den meisten Lehrbuchern der Neuroradiologie gar nicht erwahnt weshalb uns diese Studie gerechtfertigt erscheint

Die Zahl der Schadelnahte ist verhaltnismassig gross Deshalb erschien es uns wesentlich die Suturen der Jugendlichen und Erwachsenen schematisch in den verschiedenen Ansichten des Schadels darzustellen Diese schematischen Darstellungen orientieren uns am ehesten uber die Lage aber auch uber die Schwierigkeiten der rontgenologischen Darstellung der Suturen (Abb 1 und 2)

Mit den ublichen rontgenologischen Untersuchungsmethoden ist am Lebenden der Grossteil der Suturen kaum darstellbar CROCELLA hat die einzelnen Suturen des Skelettschadels mit positivem Kontrastmittel bezeichnet und versucht, sie rontgenologisch darzustellen Seine Untersuchungen haben bewiesen dass die Schadelnahte rontgenologisch meist nicht abzubilden sind Es sind praktisch nur die Suturen des Gehirnschadels darzustellen, weshalb auch wir nur diese Schadelnahte behandeln werden

In den klassischen drei Dimensionen sind die Suturen einerseits wegen ihrer beidseitigen symmetrischen Lage und daraus folgender Aufeinanderprojizierung anderseits infolge der verticalen Lage der Sutura sagittalis in der

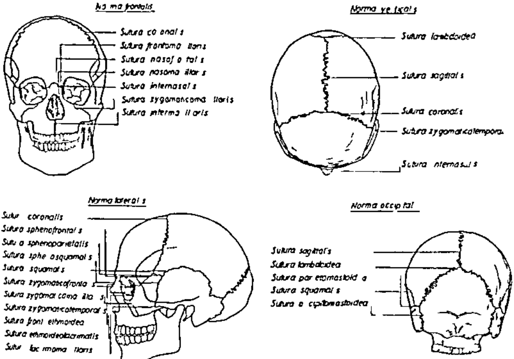


Abb 1 Schematische Darstellung der Schädelnähte bei Jugendlichen und jungeren Erwachsenen Vorderansicht des Schadels—Norma frontalis der Anthropologen Seitenansicht des Schadels—Norma lateralis Obenansicht des Schadels—Norma verticalis Hintenansicht des Schädels—Norma os occipitalis

Mittellinie schwer darzustellen Wenn der Kopf bzw Skelettschadel zur vertikalen Achse 20° bis 45° gelagert wird sind die Suturen gut dargestellt

Der Verlauf der Suturen ist keineswegs geradlinig, sondern zickzackartig Die Zacken konnen nach dem Verfahren von Oppenheim zahlengemass bestimmt und entsprechenderweise quantitativ ausgedruckt werden Wenngleich bedeutende individuelle Unterscheide bezuglich der Zahlenwerte der Zacken leicht feststellbar sind konnen wir diese Differenzen physiologisch bzw pathophysiologisch nicht deuten weshalb deren Behandlung uberflussig ware Die einzelnen Suturen werden von den Anthropologen teilweise auf Grund ihrer Gezacktheit weiter eingeteilt

Abb 2b gibt eine flachenhafte Darstellung der Anteile der Suturen Diese anthropologischen Bezeichnungen der Suturenanteile werden von medizinischer Seite nicht verwendet weshalb wir von ihrer Besprechung absehen mochten

Bis zum 16 Jahrhundert war die Meinung allgemein dass es Menschen ohne Suturen gabe wahrend diese bei gewissen anderen Menschengruppen, Rassen usw vorhanden seien Diese Differenzen verbunden mit Wachstum und Grosse des Gehirnes wurden als Wertunderschiede der einzelnen Menschen

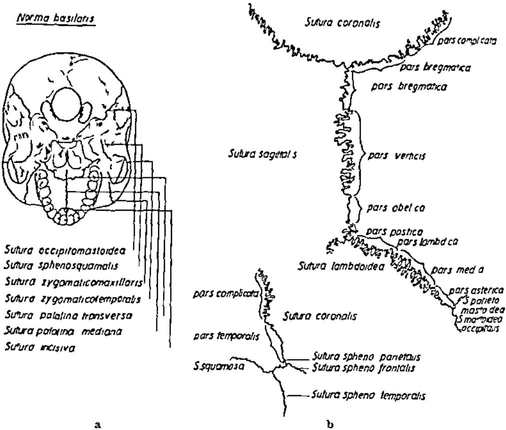
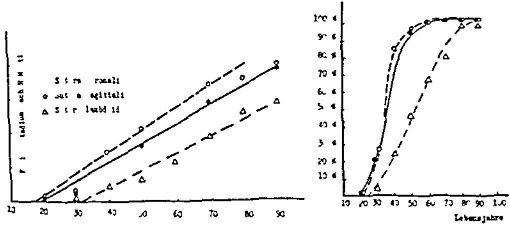


Abb. 2. a) Schematische Darstellung der Schädelnähte von unten betrachtet — Norma basilaris des Skelettschädels mit den eingetragenen Schädelnähte. b) Die Suturen des Gehirnschädels in einer Fläche dargestellt mit Angabe der einzelnen Anteilen der Schädelnähte

gruppen, Rassen u. a. betrachtet, eine vollkommen unwissenschaftliche Theorie, welche durch die grundlegenden Untersuchungen von TODD und Mitarbeiter widergelegt wurde.

Die Fontanellen der Neugeborenen und der Säuglinge werden im Laufe des Wachstums zu schmalen bindegewebigen Schädelnähten transformiert, um im weiteren zu fusionieren, zu verknöchern. Beim Erwachsenen sind meist nur gewisse Schädelnähte vorhanden. Als physiologische Variationen ohne praktische klinische Bedeutung können aber auch Suturen bestehen bleiben, wie z. B. die Sutura frontalis (metopica der Anthropologen) und die Sutura mendosa (transversa).

Zwischen der oberen und der unteren Schuppe des Hinterhauptbeines liegt die Sutura transversa, die schon zur Zeit der Geburt verknöchert ist. Sie bleibt aber meist nur an den lateralen Anteilen offen und man spricht von einer Sutura mendosa. Die Seltenheit der Sutura mendosa kann bei traumatologischen Fällen eine Schädelknochenfraktur oder Fissur nachahmen und hat



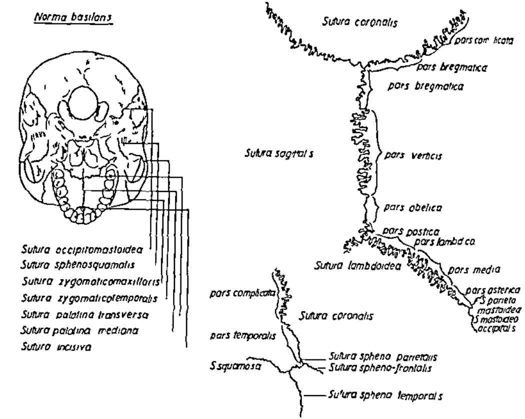
a b

Abb 3 Verknöcherung der Gehirnschädelnähte als Funktion des Lebensalters a) Der Fusionszustand wird nach dem Vorschlage von MARTIN in vier Stadien eingeteilt und die Mittelwerte der Stadien der einzelnen Altersgruppen werden dargestellt b) Die schon fusionierten bzw im Fusionszustand sich befindenden Nähte sind in aller untersuchten Fälle des betreffenden Lebensalters dargestellt

deshalb auch diagnostische Bedeutung Über ihr Auftreten und eventuelle klinische Bedeutung ist nichts bekannt

Zwischen den beidseitigen Stirnbeinen ist zur Zeit der Geburt und im Säuglingsalter eine Sutura frontalis vorhanden die in einer gewissen Anzahl der Fälle — in unserem Material rund in 6 % — auch bei Erwachsenen bestehen bleiben kann Diese Sutura metopica wurde hinsichtlich ihrer phylogenetischen Bedeutung und physiopathologischen Rolle viel untersucht (ASHLEY MONTAGU URISON, VAN BORK FELTKAMP u a) TORGERSEN hat in seinen ausgedehnten Untersuchungen am skandinavischen, WEINERT am deutschen Material festgestellt dass bei Vorhandensein der Sutura metopica die Stirnhöhle fehlt bzw recht klein ist HAAS und wir selbst, konnten an einem grossen ungarischen Material einen derartigen Zusammenhang hingegen nicht bestätigen sondern eine auffallende Grössenvariation, ja sogar Vergrösserungen beobachten Wir denken diesbezüglich an ethnisch genetische Differenzen umsomehr, da nach TORGERSEN, URISON u a das Bestehenbleiben der Sutura metopica der sog Metopismus in einer grossen Mehrzahl der Fälle erblich bedingt ist

Die anthropologische und gerichtlich medizinische Literatur befasst sich recht ausführlich mit dem Vorgang der Fusion der Schädelnähte da nach einer langen Reihe von Autoren — ausführliche Literatur diesbezüglich ist in den Mitteilungen von LACHMAN und TODD zu ersehen — das Lebensalter an Hand des Fortschreitens der Abrasion der Zähne und des Fusionszustandes der Suturen mit grosser Genauigkeit angegeben werden kann Die Suturen der Gehirnschädels verhalten sich hinsichtlich der zeitlichen Verlaufes der Fusion am regelmässigsten wo durch eine Lebensalterbestimmung mit gewisser Genauigkeit auch am Lebenden möglich ist



a b

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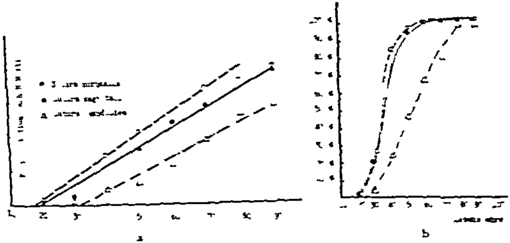


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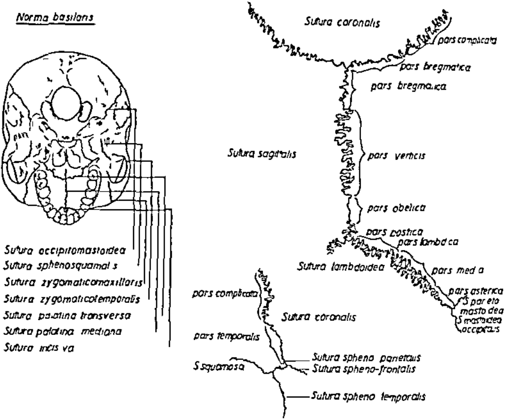
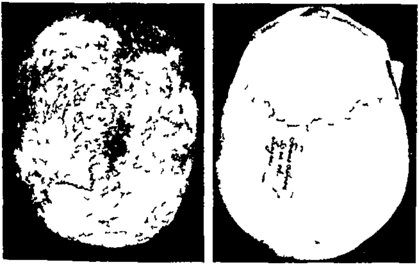


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a b

Abb 5 a) Asymmetrische Verknocherung der Gehirnschädelnähte Die linke Halfte der Kranznaht ist schon vollkommen verschwommen während die rechte Hälfte noch offen ist Eine Schädeldeformierung ist in diesem Falle nicht fest zustellen b) Die sagittale und lambdoide Naht ist praktisch vollkommen fusioniert bei Persistenz der Sutura coronalis

2 Man kann auch die Prozentzahl der Falle, bei denen die Suturen schon fusioniert bzw in Verschmelzung begriffen sind angeben Abb 3b orientiert diesbezuglich uber die Funktion des Lebensalters Es ist gut zu ersehen dass die Fusion der einzelnen Suturen regelmassig und in charakteristischen Etappen verlauft Wir haben die von MANNS vor drei Jahrzehnten bestimmten Fusionsverhaltnisse ebenfalls bearbeitet und mit unseren Daten verglichen Es stellte sich klar heraus, dass im Vergleich zu den Zahlenwerten von MANNS keine Unterschiede im zeitlichen Verlauf der Verknocherung der Schadelnahte vorhanden sind So bleibt der Fusionsvorgang praktisch unverandert Diese Tatsache mochten wir deswegen besonders betonen da die Fusion der Epiphysenlinien der langen Rohrenknochen sich keineswegs derartig verhalt da sie — nach unseren eigenen Untersuchungen — heutzutage wesentlich rascher stattfindet als fruher und so einen Teil der wohlbekannten Entwicklungsakzeleration der heutigen Jugend ausdruckt

Wenn wir in einem Diagramm den prozentuellen Zahlenwert der Fusion der Schadelnahte als Funktion des logarithmischen Wertes des Lebensalters auftragen (Abb 4) erhalten wir fur die einzelnen Suturen einen geradlinigen Verlauf Es ist daraus gut zu ersehen dass die Verschmelzung der Schadelnahte — zumindestens des Gehirnschadels — mit dem Fortschreiten des Lebensalters sich regelmassig vollzieht und dass sie mit dem Altern immer mehr fortschreitet Wir haben die Zahlenwerte fur die beiden Geschlechter

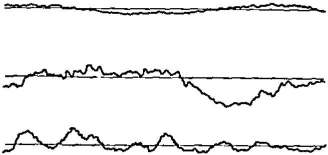


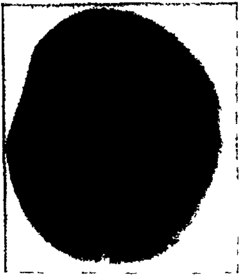
Abb. 6. Photometrische Densigramme der Sutura lambdoidea. Die obere Kurve ist bei Jugendlichen vorhanden und entspricht einer breiten bandartigen Sutura. Die mittlere Kurve ist bei Erwachsenen zu finden, bei denen die Fusion der Sutura schon begonnen hat. Die untere Kurve entspricht der schon verknöcherten Naht. Von einer Randbildung (marginalen Kondensation) kann nicht gesprochen werden

nicht separat angegeben, da sie dem Schrifttum nach, aber auch nach unseren eigenen Feststellungen, bei beiden Geschlechtern identischerweise verlaufen. Wir konnten weiterhin ebenfalls beobachten, dass die Fusionsverhältnisse der Sutura coronalis und sagittalis recht ähnlich sind. Immerhin kann als Variation vorkommen, dass eine dieser Nähte früher als die andere verschmilzt (Abb. 5a). Die Kranznaht verschmilzt früher als die Sutura sagittalis.

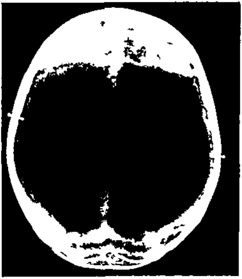
Die Verschmelzung der Schädelnähte kann frühzeitig oder verspätet eintreten. Die frühzeitige Fusion der Suturen deformiert häufig die Schädelform (Craniostenosis), wobei die Fusio praecox sich auf eine Seite beschränkt, und mit oder ohne Schädeldeformation einhergehen kann (Abb. 5b). Die verschiedenen Formen der Craniostenosen zu besprechen würde unsere Fragestellung aber wesentlich überschreiten (diesbezügliche, ausführliche Literatur ist in der Arbeit von LAITINEN zu finden). Eine Verspätung der Verschmelzung findet im Falle von endokranieller Druckerhöhung statt und ist meist mit einer bestehenden oder vorübergehenden Diastase der Schädelnaht verbunden.

Der Prozess der Verschmelzung der Suturen wurde histologisch oft und eingehend untersucht (LAITINEN u. a.). Diesbezügliche röntgenologische Untersuchungen fehlten jedoch. Wir haben an Hand der röntgenologischen Schattendichte der fusionierten oder in Fusion befindlichen Schädelnähte versucht zum Studium der Suturenfusionierung beizutragen. Es wurde eine Anzahl Röntgenaufnahmen von Schädelkalotten optischdensigraphisch untersucht. (Die photometrische Densigraphie wurde dankenswerterweise von Doktor L. Kállay aus dem Staatsinstitut für Ernährungswissenschaft Budapest ausgeführt.) Die Densigraphie der Schädelnähte, von welchen einige in Abb. 6 dargestellt sind, beweisen, dass die Verschmelzung ohne irgendwelche marginale Condensation (Randbildung der benachbarten Belegknochen) stattfindet. Im Laufe der Fusion wird einfach fortschreitend die Nahtspalte mit Knochensubstanz erfüllt. Die von ZIMMER abgebildete Randbildung der verknöchernden Schädelnaht dürfte durch einen optischen Effekt verursacht sein.

Bei Anfertigung von Röntgenaufnahmen der Schädelkalotte wird die Röntgenröhre der Kalotte soweit als möglich genähert und der gegenüberliegenden Kalotte ein Film mit flexibler Verstärkerfolie (CAWO) direkt angelegt. Diese, von den italienischen Autoren TURANO, RAGUGNO und CONGIU u. a. als



a



b

Abb 7 Nahröntgenaufnahmen der Sutura sagittalis der Schädelkalotte a) Die Aufnahme wird mit von aussen angebrachter Röhre und von innen angelegtem Film gemacht b) Die Röhre wurde von innen angebracht und Film von aussen aufgelegt

Plesiographie (Nahaufnahmetechnik) bezeichnete Methode darstellt eine einzelne Schicht der Knochenstruktur Abb 7 zeigt auf den unterschiedlichen Verschmelzungsvorgang beider Tabulae cranii Unsere Untersuchungen sprechen dafur dass die Verschmelzung der Schadelnahte in der Tiefe der Suturen beginnt, nach innen in Richtung der Tabula externa Es ist zu betonen, dass die Suturen beider Tabulae des Schadels sowohl gleichzeitig verschmelzen konnen als auch dass die Fusion der ausseren Schadelflache etwas langsamer vorsich gehen kann Diese Unterschiede konnen vermutlich in der Zukunft eine differentialdiagnostische Bedeutung erlangen

ZUSAMMENFASSUNG

Die Rontgenologie der Schadelnahte wurde bisher kaum studiert Bei der rontgenologisch anthropologischen Bearbeitung eines grossen Material von Rontgenaufnahmen von Schadeln von Patienten mit Schadeltrauma und von Skelettschadeln waren Gesetzmassigkeiten hinsichtlich des zeitlichen Verlaufes der Nahtfusion wie auch des Fusionsmechanismus nachzuweisen

SUMMARY

Roentgenology of the sutures of the skull does not appear to have been previously studied A roentgenologic anthropologic investigation of a large material of roentgen films of skulls of living subjects and morbid specimens that had sustained injury revealed a definite pattern in the chronology and mechanism of the fusion of the sutures

RÉSUMÉ

Il semble que la radiologie des sutures crâniennes n ait pas encore été étudiée L étude radio-anthropologique d un grand nombre de radiographies du crâne de sujets vivants et de pieces anatomiques ayant subi un traumatisme a montré que la chronologie et le mécanisme de la fusion des sutures se conforment à un schéma précis

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AUS DER RONTGENABTEILUNG DER NERVENKLINIK (DIRECTOR. PROF DR K KOLLE)
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RÖNTGENAUFNAHMEN VON PRÄPARATEN FÖTALER SCHÄDEL

von

K. DECKER

Die verschiedenartigen Varianten der Knochenbildung am atlanto-okzipitalen Übergang werden im allgemeinen als Entwicklungsstorungen angesehen Es lag daher nahe die Entwicklung der knochernen Schadelbasis und der ersten Halswirbel an Rontgenaufnahmen von Foten zu verfolgen um Einzelheiten der Verknocherung der Schadelbasis erkennen zu konnen Einpragsame und ubersichtliche Vergroßerungsaufnahmen ermoglichte die Anwendung eines kornlosen Filmes wie er fur technische Aufnahmen verwendet wird (Structurix D 7 bzw D 4) der es erlaubte auch die ersten Verknocherungszonen an der Schadelbasis gut zu erkennen Die Detailerkennbarkeit wurde durch Umkopie einiger Filme noch verbessert

Am Ende des 3 Entwicklungsmonats in der zehnten bis zwolften Woche beginnen sich am Schadel und an der Halswirbelsaule die ersten Verknocherungen zu zeigen wenn der Embryo weniger als 10 cm misst und der bitemporale Schadeldurchmesser etwa 2 cm betragt Die ersten Zeichen einer Verknocherung erscheinen in der Okzipitalschuppe aber auch schon an manchen Stellen der tangential getroffenen Abschnitte der Schadelkalotte glaubt man sie erkennen zu konnen



Abb. 1. Seitliche Schädelaufnahme eines Fötus von 10,3 cm Scheitel-Steißlänge (etwa Mitte des 4. Fötalmonats) und einem bitemporalen Schädeldurchmesser von 3,5 cm (52 kV, Bel. 4,0 Sek. auf Structurix D 4). Im Bereich der Schädelkalotte ist die feinfiederige Zeichnung von Frontal- und Okzipitalschuppe erkennbar, weniger deutlich im Parietalbereich. In der Schädelbasis zeigt sich der Klivus neben den lateralen Knochenkernen des Okzipitalbeins und der getrennten Knochenanlage der einzelnen Keilbeinkerne. Ein Teil des Gesichtsschädels bereits deutlich verknöchert, auch das Nasenbein ungewöhnlich deutlich gezeichnet.



Abb. 2. Seitliche Schädelaufnahme (in doppelter Vergrößerung) eines abgetrennten Präparates mit einem bitemporalen Schädeldurchmesser von 6 cm, etwa dem 5. Fötalmonat entsprechend. Durch die Entwicklung der Verknöcherung um das Labyrinth ist der Klivus nicht mehr zu erkennen. Sämtliche Nähte des Schädeldaches sind breit, die fiederige Knochenzeichnung vor allem im Parietalbereich deutlich.

Im Alter von 4 Monaten ist die Schädelbasis mit typischen Verknöcherungszentren versehen, der Klivus durchgehend verknöchert, die Knochenkerne des Keilbeins aber noch getrennt. Relativ kräftig ist wieder Frontal- und Okzipitalschuppe gezeichnet. Das Nasenbein ist stets deutlich erkennbar (Abb. 1).

Etwa einen Monat später beginnt — gleichzeitig mit dem Schluß des *Keilbeines — das Felsenbein zu verknöchern.* Die ungewöhnliche *Größe* der



a



b

Abb 3 Tomogramme von Präparaten a) Präparat wie in Abb 1 Klivus Okzipitalschuppe einzelne Keilbeinkerne und Frontalschuppe neben der Anlage des Nasenbeins deutlicher zu erkennen b) Gleiches Präparat wie Abb 2 Die tomografische Untersuchung erlaubt jetzt den Klivus darzustellen der früher durch die Überlagerung mit den Strukturen des Felsenbeins nicht erkennbar war

Gehörknöchelchen und des Innenohres überraschen Einzelheiten des Klivus sind in den genannten Monaten aber nur mehr durch Tomogramme erkennbar, da die Strukturen des Felsenbeines ihn völlig überdecken (Abb 2) Bei einem ausgetragenen Säugling haben sich die Größenverhältnisse schon wieder dem Erwachsenen angeglichen

Wendet man die tomografische Untersuchung an, um Einzelheiten der Schädelbasis genauer erkennen zu können findet man immer sowohl im 3 wie im 4 Monat der Entwicklung bereits den Klivus als solide Platte (Abb 3)

Aufnahmen der Schädelbasis sind besonders im 4 und 5 Entwicklungsmonat einprägsam wenn die Verknöcherung der Felsenbeine die im Vergleich zur übrigen Schädelbasis riesigen Bogengänge und die Schnecke zu umgeben beginnen Auch die einzelnen Gehörknöchelchen sind zu diesem Zeitpunkt schon erkennbar

Trotz eines Beobachtungsgutes von fast 100 Foten aller Entwicklungsstufen meist des 3 bis 5 Monats konnten wir bisher keine atlanto-okzipitale Übergangsmißbildung finden Wir waren vielmehr von der klaren Zeichnung des Schädelbasiswinkels und der frühen konstanten Verknöcherung des Klivus soweit er dem Os occipitale angehört beeindruckt Ein Teil der Köpfe wurde auch nach weiterer Präparation zur Darstellung der einzelnen Knochenanlagen am atlanto-okzipitalen Übergang untersucht (Abb 5)

Eine andere Tatsache aber überraschte Weit über die Hälfte der untersuchten Foten ließen bei der oft gleichzeitig vorhandenen Luftfüllung schwere Entwicklungsstörungen des Gehirns als Ursache des Fruchttodes erkennen



Abb 4 Basisaufnahme des gleichen Praparates wie Abb 2 und 3b) Deutliche Darstellung von Mittel und Innenohr durch Zeichnung der umgebenden Knochenzellen



Abb 5 Untersuchungen des atlanto-okzipitalen Übergangs nach Abtragung von Teilen des Gesichts schadels und Kalotte mit Hirn Praparat eines Embryos von 11 5 cm Scheilte Steißlange und 3 5 cm bitemporalen Schadeldurchmesser Die Knochenan lage der Kondylen ist deutlich erkennbar auch die einzelnen Verknocherungszentren der Halswir belkorper sind gut abgegrenzt Doppelte Vergroß erung auf Structurix D 7 (42 kV Bel 4 0 Sek)

Einzelheiten dieser Methode zur Erkennung von Entwicklungsstorungen des embryonalen Gehirns im Praparat mussen aber noch gesondert dargestellt werden, da sie eine Vielzahl von ungewohnlichen Storungen erkennen lassen

ZUSAMMENFASSUNG

Bericht uber Technik und Ergebnisse von Rontgenaufnahmen fötaler Schadelpraparate mit einer Untersuchungsmethode wie sie fur die Materialprufung angewandt wird Auffallend ist bei den untersuchten Praparaten eine starke Haufung von Hirnmissbildungen wie die gleichzeitige Luftfullung der Schadelkammern zeigt

SUMMARY

The technique and results obtained in the roentgen examination of foetal skull specimens by a method similar to that employed in industrial roentgenography are described A feature of the specimens examined was the frequent occurrence of cerebral malformations manifest by air filling of the ventricles

RÉSUMÉ

Description de la technique et des résultats obtenus par l examen radiologique de cranes foetaux avec une méthode analogue a celle qui est utilisee en radiographie industrielle La fréquence des malformations cérébrales rendues visibles par l injection d air des ventricules est une des caractéristiques des pieces examinées

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FAMILIAL ASPECTS OF RADIOLOGIC CHANGES IN DYSTROPHIA MYOTONICA

by

I Isherwood and C Mawdsley

In 1920 Scharnke and Full recorded the presence of large frontal sinuses in one case of dystrophia myotonica *Rouques in 1931 first drew attention to* the occasional occurrence in this disease of a thickened skull vault large frontal sinuses and a small sella Hyperostosis of the cranial vault in dystrophia myotonica has been noted by several observers Fagin (1946) De Oliveira and Mosinger (1951), Jequier (1950) Caughey and Brown (1950) and Caughey (1952), (1958) and (1960) Caughey and Brown suggested that these abnormal radiologic features found in the skull should be accepted as a variable feature of the disease Walton and Warrick (1954) reviewed 17 cases of dystrophia myotonica together with 6 relatives comparing them with a series of normal subjects and confirmed the high incidence of a thickened skull vault and small pituitary fossa

Material and Methods

The purpose of this paper is to review briefly the skull changes found in 46 patients with fully developed dystrophia myotonica and to present a study of the radiologic chages found in 60 relatives of these affected patients In addition 147 skull roentgenograms of patients attending the casualty department have been reviewed as a control group Lateral roentgenograms of the skull were obtained with the central ray directed 2 5 cm above and 2 5 cm in front of the external auditory meatus and a focus film distance of about 100 cm The following radiologic features were noted

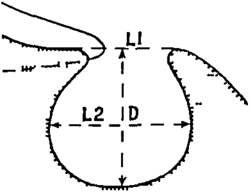


Fig 1 Schematic drawing of the pituitary fossa with lines of measurement indicated

1 *Skull vault thickness* Three measurements of vault thickness were made from the lateral skull roentgenogram (a) frontal bone — above the frontal sinus, (b) vertex, (c) occipital bone — above the occipital protuberance The sum of these measurements was termed the vault index

2 *Hyperostosis* When present it was recorded with reference to the classification suggested by MOORE (1955), viz

hyperostosis frontalis — deposits of new bone on the inner table of the frontal bone,

nebula frontalis — a triangular or ellipsoidal area of increased density in the frontal region extending down from a base on the sagittal plane

hyperostosis condensa diffusa — generalised thickening of the calvarium with an increase in density of the diploe

hyperostosis frontalis parietalis — deposits of new bone on the inner tables of the frontal and parietal bones

3 *Pituitary fossa* Two measurements of the pituitary fossa were made from the lateral skull roentgenogram (Fig 1) (a) depth — of a perpendicular dropped from a line joining the tuberculum and the dorsum (i e the line of the diaphragma sella L 1) to the deepest point of the pituitary fossa (b) length — the maximum diameter of the pituitary fossa The multiple of these measurements (i e D L 2) was termed pituitary index

4 *Frontal sinuses* A subjective assessment of the size of the frontal sinuses based on height and depth was made and recorded normal large or 'very large



Fig 2 Lateral skull roentgenogram in dystrophia myotonica The vault index is markedly increased hyperostosis frontalis parietalis

5 *Other air sinuses* A record was made of the antra, ethmoids, sphenoids and the mastoids in cases where these groups of air cells were unusually large

6 *Mandible* The angle, length and width of the jaw were measured, and an assessment of any degree of prognathism was made

7 *Chest* Roentgen examination of the chest of all patients was performed The individual clinical features of the disease were recorded in each case

Results

A detailed analysis of the findings in our review of 46 cases of established dystrophia myotonica is being published elsewhere (MAWDSLEY & ISHERWOOD 1962) A summary is presented below

One or more abnormal radiologic features were observed in 39 cases Seven (5 males and 2 females) showed no radiologic abnormality

1 *Skull thickness* Statistical analysis of the control group and of the 46 cases with dystrophia myotonica demonstrated that not only are there cases in the abnormal group with thicker skulls, but there is a general tendency for cases with dystrophia myotonica to have thicker skulls than normal It is estimated that more than *half of the cases with dystrophia myotonica* have a thickened skull vault (Fig 2)



Fig 3 Lateral skull roentgenogram in dystrophia myotonica Hyperostosis (nebula frontalis)

2 *Hyperostosis* The incidence of hyperostosis was significantly increased in the dystrophia myotonica group compared with the control group (Fig 3)

3 *Pituitary fossa* Analysis of pituitary fossa size in the control group and in the dystrophia myotonica group demonstrated an increased incidence of a small pituitary fossa in dystrophia myotonica A subjective assessment of the pituitary fossa showed that in the control group of 147 cases 130 were regarded as normal 15 small, and 2 very small, whereas in the dystrophia myotonica group of 46 cases, 25 were regarded as normal 18 small and 3 very small — close correlation with the statistical analysis A small sella can be anticipated in about one third of cases of dystrophia myotonica (Fig 4)

4 *Frontal sinuses* These were abnormally large in 38 % of cases of dystrophia myotonica (Fig 5)

5 *Other sinuses* No significant difference between the dystrophia myotonica group and the control group was found

6 *Mandible* There was no significant difference in the angle length or width of the mandible between the dystrophia myotonica group and the control group

7 *Chest* No significant abnormality was demonstrated in any chest roentgenograms

There was no significant correlation between any single clinical feature or the severity of affection and the occurrence of radiologic changes



Fig 4 Lateral skull roentgenogram in dystrophia myotonica A very small sella

Family study

Twenty four propositi with dystrophia myotonica from 19 families formed the basis of this family review and 60 relatives from these nineteen families were studied The clinical classification of the findings is recorded below

Clinical classification		Parents	Siblings	Children	Children of siblings	Total
Dystrophia myotonica		2	5	2	—	9
Cataracts only		3	2	—	—	5
Myotonia only		—	—	3	—	3
No abnormality		14	16	3	10	43
	Total	19	23	8	10	

Of the 60 relatives, 9 were found to have fully developed disease 5 had cataracts only, and 3, all children of propositi (two boys, aged 11 and 8 and one girl, aged 12) were found to have myotonia but no other features of dystrophia myotonica In 43 relatives no clinical abnormalities were found

The fully developed cases of dystrophia myotonica were included in the earlier survey and were found to have one or more of the previously noted radiologic features In the group of five relatives with cataract, the mean vault index and 'mean pituitary index showed no statistical difference from the control group Large frontal sinuses were observed in two cases There is no evidence therefore, in this group of relatives with cataracts, of any signif icant radiologic features



Fig 5 Roentgenograms of the skull in dystrophia myotonica Large frontal sinuses

The three children with myotonia could only be considered individually No abnormality of the skull vault or frontal sinuses was demonstrable The two boys aged 8 and 11, had a 'mean pituitary index' of 48 which is a low value SILVERMAN (1959) quoted radiologic standards for the size of the pituitary fossa from infancy to adolescence Adopting SILVERMAN's criteria of measurements in these cases the pituitary fossa size was below the accepted normal value for the age of these children It is difficult to draw conclusions from so few cases but the findings suggest that early radiologic features may be present even at this age Further long term follow up would be most interesting in these patients

In the unaffected group of adult relatives the 'mean vault index' and 'mean pituitary index' were not significantly different from the control group The frontal sinuses were found to be large in one case Hyperostosis was found in 3 patients including one male again this is not a significant number Among the relatives 13 unaffected children were found none of whom showed any significant abnormality

Conclusions

In our review of the abnormalities in patients with dystrophia myotonica we agree with previous authors on the following points An increase in thickness of the skull vault is the most significant radiologic feature of dystrophia myotonica and occurs in at least half of the fully established cases The general incidence of hyperostosis of the skull vault is increased in dystrophia myotonica with a marked increase in the number of male patients affected A small pituitary fossa is a less constant abnormality but can be anticipated in about one third of fully established cases of dystrophia myotonica

Large frontal sinuses in dystrophia myotonica occur with far higher fre-

quency than normal When they are found in combination with other radio logic features, the appearances may be diagnostic

We found no significant association between any individual clinical feature and abnormal skull appearances Severity of affection bore no constant relation to the occurrence or extent of the radiologic changes

In the present study of families, relatives of propositi were found with radiologic changes, but all were on examination found to have clinical evidence of disease JEQUIER (1950), in discussing the aetiology of the disease, suggested that both the muscular disease and the skull changes might be due to a single neuro endocrine disorder, or to different manifestations of a single gene, or to two different genes arising together by chance in certain families The last hypothesis was favoured by WALTON and WARRICK (1954) Our evidence suggests that the radiologic changes occur only in conjunction with clinical evidence of dystrophia myotonica, indicating that the inheritance of clinical disease and of skull changes is probably by a single gene

It seems possible that some radiologic changes may occur where only myotonia is present in children Further long term follow up will be very valuable in these cases

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SUMMARY

Changes found in skull roentgenograms of 46 patients with dystrophia myotonica are reviewed Hyperostosis thickening of the vault and a small pituitary fossa were found to occur much more frequently in dystrophia myotonica than in a control group Sixty relatives of patients with dystrophia myotonica were studied by similar methods and measurements from the roentgenograms compared with those of the control group Significant radiologic changes occurred only in those relatives who showed clinical features of dystrophia myotonica

ZUSAMMENFASSUNG

Veranderungen des Schadels im Rontgenbild bei Dystrophia myotonica wurden an 46 Patienten studiert Hyperostosis Verdickung der Kalotte sowie eine kleine Sella wurden bei Dystrophia myotonica bedeutend haufiger gefunden als bei einer gesunden Kontrollgruppe Sechzig Verwandte dieser Patienten wurden mit denselben Methoden untersucht und die Messergebnisse des Rontgenbildes mit denen der Kontrollen verglichen Signifikante Veranderungen waren nur bei den Verwandten zu entdecken die klinische Zeichen von Dystrophia myotonica zeigten

RÉSUMÉ

Les auteurs decrivent les signes radiologiques qu ils ont trouves sur les radiograph es du crane de 46 malades atteints de dystrophie myotonique L hyperostose l epaississement de la voute et une petite selle turcique sont trouvés beaucoup plus souvent dans les cas de dystrophie myotonique que chez les sujets témoins Soixante membres de la famille de malades atteints de dystrophie myotonique ont été examines par la même methode et les mesures faites sur leurs radiographies ont été comparées avec celles du groupe témoin Il n y a d anomalies radiologiques significatives que chez les sujets qui presentent des signes cliniques de dystrophie myotonique

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VALUE OF TOMOGRAPHY AND SUBDURAL PNEUMOGRAPHY IN SUBFRONTAL FRACTURES

by

ANTONY JEFFERSON and NORMAN LEWTAS

The successful identification of skull fractures which bring the intracranial contents into communication with the nasal cavity or the frontal, ethmoidal or sphenoidal sinuses, sets a stimulating problem both to the radiologist and to the neurological surgeon. For some people, the indication for operative treatment of the subfrontal fracture is persistent cerebrospinal rhinorrhoea. However, some patients with subfrontal fractures in whom rhinorrhoea has ceased spontaneously, subsequently develop meningitis. Moreover, certain patients with subfrontal fractures develop meningitis without experiencing any cerebrospinal rhinorrhoea. There is a tendency to regard purulent meningitis as a condition which can always be cured with modern antibiotics. Yet in our own experience this is not always true. One example will suffice.

In November 1958 a male aged 19 was referred to us because it had been thought erroneously that his pituitary fossa was larger than normal. One month previously he had suffered a head injury. At the time of the accident there was a little bleeding from his right nostril but he was never noted to have any cerebrospinal rhinorrhoea nor was there any air within his skull. He had a right frontal fracture. Apart from diminished olfaction (probably caused by chronic catarrh) he had no neurologic abnormalities. It was appreciated that the



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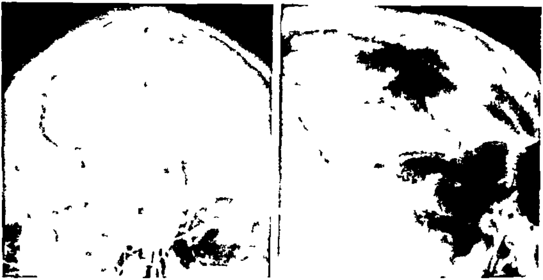
Fig 1 a) Coronal tomogram at 2 0 cm Clear bone outline except in region of cribriform plate cribriform area less distinct owing to thinner bone (Right and left cribriform areas are not necessarily symmetrical in extent) The crista galli is clearly seen b) Sagittal tomogram 0 5 cm from midline Roof of ethmoid cells is outlined in a well defined and unbroken line

fracture might involve the posterior wall of his right frontal sinus or the roof of his ethmoidal air cells Detailed radiography appeared to show no evidence of such fractures and he was discharged from further supervision Three and a half months later he developed pneumococcal meningitis and in spite of prompt and energetic treatment died within 48 hours At autopsy the undersurface of his right frontal lobe was found to be widely adherent to the floor of the anterior fossa and there was a fracture of the orbital plate running into the posterior ethmoidal cells

The experience of this case in which cerebrospinal rhinorrhoea was never observed and the first attack of meningitis proved fatal, made us determine to try to improve our methods of diagnosis We felt that we required a more certain method of recognising the dangerous fractures, and we appreciated that there would be an enormous advantage if it were possible radiologically to predict the presence of a dural defect in relation to the fractures The work described in this communication has been carried out in an effort to achieve these advantages

Material and Methods It seemed likely that tomography would be of help in identifying these fractures This opinion was held because even oblique and tangential projections make it difficult to obtain an unimpeded view of the areas in which the fractures may lie Initially tomography was limited to the sagittal plane, but more recently both lateral and anteroposterior tomograms have been employed in each case Thirteen patients have been examined by tomography

We have approached the problem of the demonstration of a dural laceration in the presence of a subfrontal fracture but without cerebrospinal rhinorrhoea on the premise that this state of affairs only occurs when the brain is adherent

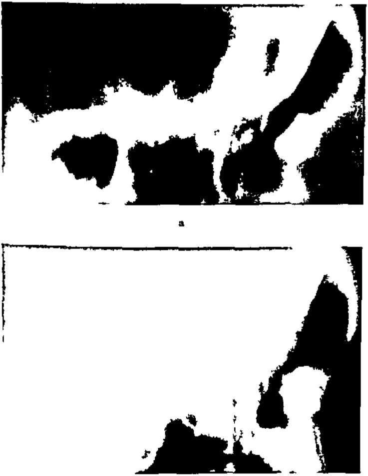


a b

Fig 2 Case 1 Right frontal fracture involving frontal and ethmoidal sinuses Oblique view in (b)

to the area of the dural defect This is a well known phenomenon (e g LEWIN 1954, BRANDT 1959) and has been fully confirmed in the present series

In order to display such adhesions we have introduced air into the frontal subdural space in 10 subjects Four of these had bilateral examinations carried out on separate occasions After premedication (usually with 1/3 grain omnopon and 1/150 grain scopolamine), and under local anaesthesia and aseptic conditions, a small scalp incision was made and a hole approximately 3 mm in diameter was made in the skull with a hand drill The site of the drill hole was usually slightly inferior to the hair line and at least 3 0 cm from the mid line A needle with a very short bevel was then introduced through the dura mater, and a total of up to 30 ml of air was gently injected until a slight positive resistance to the plunger was felt It was sometimes but not always, necessary to suture the 'stab wound in order to prevent the air from escaping In the last six cases a lumbar puncture (with withdrawal of 10 to 30 ml of spinal fluid) was carried out before the hole was drilled This avoided the possibility of accidental subarachnoid air injection in the frontal region, by allowing the cortex to fall away from the injecting needle The standard practice has been for lateral roentgenograms to be obtained with the brow up, and subsequently with the head fully extended It is sometecimes helpful to employ minimal rotation of the head in order to outline the tips of the frontal lobes and their undersurfaces in profile



a

b

Fig 3 Sagittal tomograms of same case as in fig 2 a) 0 5 cm to the left of the midline continuous ethmoid roof b) 0 5 cm to the right of the midline disruption of anterior ethmoid roof

Results

Tomography The tomograms in Fig 1 show no evidence of fracture and should be regarded as normal

An extensive fracture in the right frontal region extending backwards to involve the posterior wall of the frontal sinus and the roof of the anterior ethmoidal air cells is shown in Fig 2 (Case 1) The sagittal tomogram taken just to the left of the midline (Fig 3a) shows the normal profile extending from the frontal sinus to the sphenoidal sinus By contrast a sagittal tomogram running parallel with the fracture just to the right of the midline (Fig 3b) shows

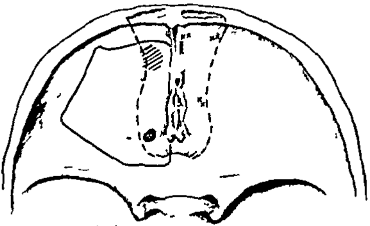


Fig 4 Case 2 Intradural bifrontal exploration operation diagram No rhinorrhoea or intracranial air Extensive left fronto temporal compound de pressed fracture

disruption of the ethmoid roof Part of the loss of bone detail may be caused by the presence of a blood clot, associated with the fracture and giving rise to a soft tissue outline

The operation findings in a man, aged 30 (Case 2), who four weeks earlier had received an extensive, compound depressed, fracture in the left anterior temporal region, are shown in Fig 4 This case required immediate surgery to deal with the depressed temporal fragments Nothing was noted at the opera tion to suggest that the dura was lacerated subfrontally However, because severe anterior temporal fractures may extend into the subfrontal region and because subfrontal fractures may in turn be associated with dural laceration, this case was investigated by sagittal tomograms The appearance immediately to the left of the midline in the region of the roof of the anterior ethmoidal air cells is shown in Fig 5a Instead of the normal continuous profile there is a slightly depressed plaque of bone in the anterior ethmoid sinus This abnor mality corresponds very precisely with the shaded area (probable defect in Fig 4), which was commented upon because it felt abnormally soft to the exploring probe Fig 5b represents a sagittal cut at the level of the molar teeth A wide fracture line is present in the orbital plate posteriorly This was not seen at operation for the overlying dura was intact (see the stippled area of Fig 4 where adherence of the brain indicates previous contusion) It will be



a b

Fig 5 Sagittal tomograms of same case as in fig 4 a) Close to the midl n depress d plate of bone in anterior ethmoid roof b) More laterally Wi le fracture line in orbital plate

recognised that this fracture which is shown in the same plane as the molar teeth could not communicate directly with any of the sinuses However we believe that it is of the greatest value to learn of the presence of such fractures by tomography, for their medial extension may involve one of the sinuses Indeed it is quite possible that the area marked definite opening into ethmoid cell in Fig 4 corresponds with a medial extension of the fracture line seen in Fig 5b

To summarise our current experience with tomography we would say that it has shown us the presence of all the fractures which have been displayed at operation Moreover, by providing us with considerable information concerning the bone detail of the anterior fossa, tomograms have given us greater confidence than we have hitherto felt in the management of cases of frontal head injury

Subdural air injections What we believe to be normal appearances are shown in Fig 6 (Case 3) These were obtained in a man of 34 who had a history of head injury some years before and was investigated after his second attack of meningitis Thorough investigation by conventional roentgenography revealed no fracture, sagittal and coronal tomograms of his anterior fossa showed no suspicious features (In addition his petrous bones were carefully scrutinised and there was no evidence of any lesion at this site) Finally with an interval of four days frontal subdural air injections were made on both sides It can be seen that the frontal pole lies well behind the back of the frontal sinus and well above the orbital plate In addition a thin streak of air may be identified



a b

Fig 8 Same case as in fig 7 Left subdural air injection a) Lateral brow up frontal pole outlined by air and shows concavity forwards b) Lateral head fully extended air would not enter subfrontal region

When admitted to hospital two months after the accident, olfaction was normal the left eye showed absence of light perception and no rhinorrhoea was observed The rest of the neurologic examination was normal Tomograms showed a fairly wide fracture line in the anterior ethmoid roof Bilateral subdural air injections were interpreted as normal, but because the patient had almost certainly experienced rhinorrhoea and because of the width of the fracture line a left frontal exploration was performed An area of just less than 1 cm in diameter in which the brain was adherent to a dural defect was displayed As seen in Fig 10 the dural defect only just impinged upon the ethmoidal air cells An appropriate intradural graft was performed

The results of our experience with subdural air injections to date may be summarised by stating that 14 examinations have been made On 5 occasions all the features of the case were such as to make verification by operation seem unnecessary With one exception (cf Fig 10) a correct prediction of the operative findings was made in the remaining nine examinations

Discussion

One of the chief enemies of logical thought concerning fractures involving the frontal and ethmoid sinuses is that most published articles are concerned largely if not wholly with cases which at some time have been known to have



a b

Fig 9 Same case as in figs 2 and 3 (Case 1) Right subdural air injection Lateral tomogram head fully extended a) Initial film air lies between tip of frontal lobe and frontal sinus b) Subsequent film air has now been manipulated to lie between orbital plate and frontal lobe

cerebrospinal rhinorrhoea, air within the skull, intracerebral abscess or meningitis Sooner or later all cases with fistulous subfrontal fractures will fit into at least one of these categories However, because the infective complications will not invariably respond to treatment we are convinced that dural lacerations must be recognised before infection develops This requires that those responsible for the care of patients with fractures of the frontal region below the hair line or fractures of the anterior temporal regions must consider the following questions

Firstly, if there is a fracture which might throw the intracranial contents into communication with nasal cavity, frontal sinus ethmoid sinus or sphenoid sinus secondly, if the dura in the presence of such a fracture is lacerated or defective thirdly if there is any possibility that the dural laceration or defect will heal without surgical intervention

We should like first to discuss the question of the spontaneous healing of the dural defect LINELL and ROBINSON (1941) described an example of fatal pneumococcal meningitis occurring five years after an initial injury which was probably uncomplicated by rhinorrhoea Autopsy disclosed that the olfactory bulb and the adjacent frontal lobe were adherent to the left plate of the ethmoid and the crista galli deviated to the right. There was pus in the ethmoidal sinuses Their photomicrograph demonstrates that the cribriform meninges were adherent to the edge of the bone defect and were, in fact prolapsed into the bony opening so that leptomeninges and nasal mucosa were

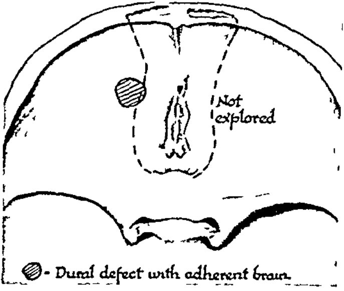


Fig 10 Case 4 Left intradural exploration operation diagram

in contact, separated only by fibrous tissue Neurological surgeons would agree that almost without exception one of the essential manoeuvres in performing an intradural graft in these cases is to separate the (often densely) adherent brain from the margins of the dural defect (e g GERMAN 1944, LEWIN 1954, BRANDT 1959) Indeed, Fig 3 of LEWIN's paper shows a typical appearance at operation which is the macroscopic equivalent of LINELL's photomicrograph Our own observations suggest that natural repair of a dural defect is only possible if prolapsed arachnoid or bone spicules do not lie between the torn dural edge CRANDALL (1957) evidently held a similar view It follows from this that whenever the arachnoid has become adherent to the margins of a dural defect there is no prospect of spontaneous healing the brain tends to prolapse through the defect and, in the course of time, presumably by continued pulsation, may either enlarge the bony defect or thin the tissues separating it from the nasal cavity so that late rhinorrhoea occurs, or infection finds its way into the skull It is not generally realised just how 'late' the infective complications may occur STENGER (1958/59) describes a patient where 31 years elapsed between a frontal injury and meningitis which was caused by a defect in the posterior wall of the frontal sinus Instances of infection occurring at lesser intervals (but nevertheless long after the original trauma) are fairly commonplace MORLEY and HETHERINGTON (1957) describe one case where 9 years elapsed between injury and evidence of dural rupture Because proper healing cannot occur when arachnoid is prolapsed into the defect, the occurrence of complications after intervals of time which may vary hugely, is entirely logical The development of infective complications at least, will de

pend upon the precise moment when bacteria come to occupy the relevant air sinus in the vulnerable subject Possibly this may never happen to some, but few, if they live long enough, are spared bacterial upper respiratory infection

One case in our series, with a large dural defect and an underlying fracture opening into the posterior ethmoidal air cells, spontaneously ceased to experience rhinorrhoea 17 weeks before operation Spontaneous cessation of rhinorrhoea without healing of the dural defect is not a unique phenomenon and its occurrence invalidates the suggestion made, for example, by ADSON and UIHLEIN (1949) also by MCKISSOCK (1952), that operation automatically becomes unnecessary if the rhinorrhoea ceases

There would be no disagreement that with persistent cerebrospinal rhinorrhoea following a fracture, full investigation is required and occasionally an exploratory operation may be necessary even though the precise site of the fistula is uncertain, e g CALVERT (1942), JENTZER (1951), TONNIS & FROWEIN (1952), LEWIN (1954)

In his thesis LACOMME (1957) mentions the view that all patients who have experienced post traumatic rhinorrhoea should be submitted to surgical exploration In a consecutive series of our cases subfrontal explorations involving the reflection of a bone flap (unilateral or bilateral) have been performed in sixteen These were selected for operation either because of cerebrospinal rhinorrhoea, or the recognition of intracranial air or in some instances, purely on unequivocal radiologic evidence of involvement of the air sinuses However, we found that these criteria were not sufficiently accurate for three of these explorations were negative, that is to say no dural defect was encountered in spite of the fact that in two of the cases there was radiologic evidence of air within the skull immediately after the injury, and the third had experienced rhinorrhoea soon after injury Subtracting these three negative explorations we are left with thirteen cases in which a dural graft was required Of these 3 (23 %) had never had cerebrospinal rhinorrhoea, nor had been noted to have air within the skull, nor had they suffered from meningitis All these cases were satisfactory in surgical outcome but it will be recalled that a further unoperated patient (mentioned in the introduction) who never had rhinorrhoea died in his first attack of meningitis

The late Cecil CALVERT in his masterly contribution (1942) to a Discussion on injuries of the frontal and ethmoidal sinuses stated that with these injuries the question as to whether or not the dura was torn was of the utmost concern CALVERT made plain that the non operative management of patients with a subfrontal dural laceration resulted in meningitis or brain abscess in 11 cases from a series of 20 He also pointed out that among his 128 cases with frontal and ethmoidal fractures, six presented with meningitis although they had no previous history of rhinorrhoea If we are to recommend operation without the

criteria of rhinorrhoea or of the continued presence of intracranial air, we must rely upon the radiologic evidence taken in conjunction with the type of injury It would be fair to state that when a fracture is seen to involve the air sinuses it has hitherto only been possible to take two courses, either all such cases are submitted to operation with the possibility of a fairly high proportion of negative' explorations, or some cases are left unoperated, with a risk of fatal complications occurring later In our view, the presence of an unhealed dural laceration must be a reasonable deduction from the available facts before exploration is performed It is because, almost without exception, adhesions between brain and dura are present with those defects which cannot heal spontaneously, that we turned to the employment of subdural air injections

The introduction of air into the subdural space was originally employed by PENFIELD and NORCROSS (1936) for the treatment of severe post traumatic headaches and for the identification of scars uniting brain to dura, which might possibly be relevant to epileptic foci Subsequently HEMMINGSON (1940), LINDGREN (1941) and MAYR and de REYA (1950—51) used this technique, mainly for the recognition of scars which they regarded as possibly relevant as a cause for post traumatic epilepsy TONNIS and LOEW (1948) modified the method by introducing the air by cisternal puncture after a preceding lumbar puncture They further suggested that subdural air could be used to outline certain extracerebral tumours None of these authors used subdural air in relation to subfrontal fractures, and their techniques either deliberately allowed air to pass simultaneously over both hemispheres or this might possibly occur spontaneously Under no circumstances do we inject air on both sides simultaneously and a check roentgenogram is always obtained before the second injection is made to be sure that no residual air remains to interfere with the interpretation of the films These procedures have not been disturbing in any of our cases or led to any significant side effects We would stress again that small areas of adhesion may possibly be overlooked Moreover, it is true that in the lateral projection adhesions between the frontal lobe and the orbital roof are more readily displayed than are those immediately above the ethmoids However, this is largely a theoretical disadvantage, for in practice we have found that areas of adhesions, large enough to be detected with certainty, will *involve the orbital plate as well as the ethmoidal roof Because our techniques* are not infallible the findings in subdural air injections must be considered together with those of tomography Indeed all the features of the case, clinical and radiological, must be considered before planning treatment

As far as we can determine there have not been any contributions in English on the systematic use of tomography for the investigation of subfrontal fractures CAIRNS, in 1937, had predicted that tomography would prove of use in these fractures Oblique views of the orbital roof designed to project in profile the postero superior wall of the frontal sinus and the roofs of the ethmoidal air cells were introduced by CALVERT (1942) and by JOHNSON and DUTT

(1944) We are well aware that in many hands these views give adequate information However, study of the sagittal and coronal tomograms taken at 0 5 cm intervals through the anterior fossa, gives us a sense of confidence by reason of the thorough scrutiny of the anterior fossa (including the sphenoidal sinus) which they afford We feel that tomograms are particularly helpful in deciding whether subdural air injections or even surgical exploration are required bilaterally TONNIS and FROWEIN (1952) recommended tomograms in certain cases, whilst BRANDT (1939) reported favourably on the regular use of tomography He recommended that it should be used more widely in the study of subfrontal fractures

It is insufficiently recognised how frequently fractures involving the air sinuses lead to grave complications at a later date Hitherto, a decision to explore the anterior fossa has at times had to be taken with inadequate objective evidence of the necessity for such an operation Although the techniques described here do not solve all the problems encountered in these cases, they greatly increase the available data and thus enhance the accuracy with which cases are selected for surgery

Conclusions

Of 16 cases operated upon for subfrontal fractures of the skull 3 had no dural defect in spite of the fact that two of these initially had air within the skull and the third had persistent cerebrospinal rhinorrhoea soon after the injury

Of the remaining 13 cases 3 (23 %) had never had cerebrospinal rhinorrhoea air within the skull or meningitis

Tomography in the coronal and sagittal planes has been found most helpful in identifying subfrontal fractures of the skull

A technique involving frontal air injections has been evolved and used to show the presence or absence of adhesions between the brain and parietes In the absence of such adhesions operation may not be required When subfrontal adhesions have been shown to be present dural repair has invariably been found necessary

Acknowledgements

We are grateful to Miss J M Osborne Mrs K Byron Thompson and Mrs N A De La Haye for their skill and interest in obtaining the roentgenograms It is a pleasure also to record the help which we have received from Mr J F V Larway and his staff in the preparation of the illustrations

SUMMARY

The value and occasional limitations of tomography and a technique of frontal subdural air injections are described and discussed with reference to a series of 16 cases subjected to operation

ZUSAMMENFASSUNG

Der Wert und die gelegentlichen Begrenzungen der Tomographie sowie eine Technik mit frontalen subduralen Luftinjektionen werden beschrieben und diskutiert Die Verfasser beziehen sich dabei auf ein Material von 16 operierten Fallen

RÉSUMÉ

Se basant sur 16 cas de fractures sous frontales vérifiés à l opération les auteurs décrivent l intérêt et les limites de la tomographie et presentent une technique d injection d air dans l espace sous dural frontal

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TOMOGRAPHY OF THE MIDDLE EAR IN SOUND-TRANSMISSION DISTURBANCES

by

BENT LANGFELDT

Tomography of the temporal bone is a method that has become indispensable for the demonstration of the finer details of this complex structure Unidirectional (linear) tomography is still the more common form of examination but the multidirectional, hypocycloid technique is gaining ground

The hypocycloid (clover leaf) movement of the roentgen tube by the polytome produces the greatest blurring of points outside the tomographic plane (FREY 1956, LANGFELDT 1960) The distance from the focus to the fulcrum is fixed at 110 cm, with a magnification factor of either 1 3 or 1 6 the thickness of the sections at a tomographic angle of swing of 48 is 1 2 mm We usually obtain two standard sets of films viz a p with the patient supine, and lateral with the patient in the lateral decubitus position The a p views are exposed at intervals of 2 mm, so that 12 exposures cover a thickness of 2 4 cm Magnification factor 1 3 other factors 90 to 105 kV about 100 mAs and 0 3 mm focus (Fig 1) The lateral views are obtained at intervals of 1 mm between the sections Experience has shown that the ossicles are best shown with a magnification factor of 1 6 (Fig 2)

Examples of the most common pathologic conditions of the middle ear are given in the following, some cases with cholesteatoma and labyrinthine fistules are illustrated in Fig 3 Luxations between the auditory ossicles which in the last few years have received increasing attention are also shown these are not an uncommon complication in severe head injury and respond well to operative measures (BRUNNER PETERSEN and STOKSTED)

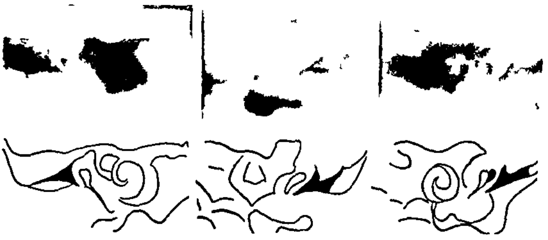


Fig 1 a) and b) Normal ossicles in two cases Cuts at 10 4 and 9 0 cm right and left sides respectively Head of malleus spur (black) of attic wall and epitympanic recess all well defined c) Normal left ossicles Cut at 8 2 cm showing head of malleus and corpus of incus (Incus and spur are black)

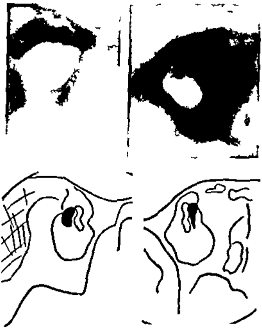


Fig 2 a) Normal ossicles left lateral cut at 2 1 cm Incus and uncudo-malleal joint clearly visible b) Right lateral cut at 9 7 cm Incus (black) and incudo-malleal joint visible

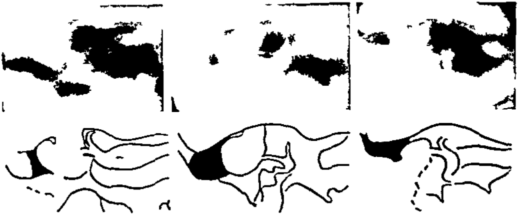


Fig 3 a) Right posterior cut at 10 0 cm Cholesteatoma and labyrinthine fistula in lateral semicircular canal ossicles absent and spur of attic wall (black) shortened b) Right posterior cut at 10 0 cm Large cholesteatoma with fistula in lateral semicircular canal ossicles absent (spur black) c) Right posterior cut at 9 8 cm. Cholesteatoma and fistula in lateral semicircular canal ossicles absent spur (black) shortened and partly destroyed

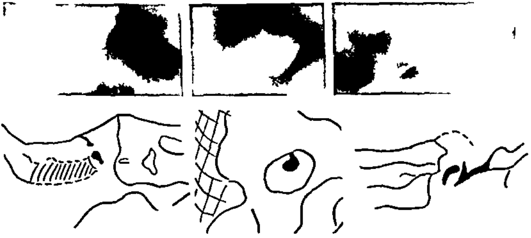


Fig 4 Case 1 Accident with explosives a) Right posterior blurred middle ear and spur (hatched) only small fragments of ossicles (black) present b) Lateral Small fragment displaced centrally c) Left posterior Normal malleus and spur (black)

Case 1 Male aged 19 Severe loss of hearing on right side following an accident with explosives left side normal Operation showed that the incus was absent the malleus was displaced centrally and rotated 180 (Fig 4)

Case 2 Boy aged 9 years Severe trauma to the head followed by loss of hearing on right side left side normal Operation showed that the incus and malleus were dislocated medially lay close together and were rotated (Fig 5)

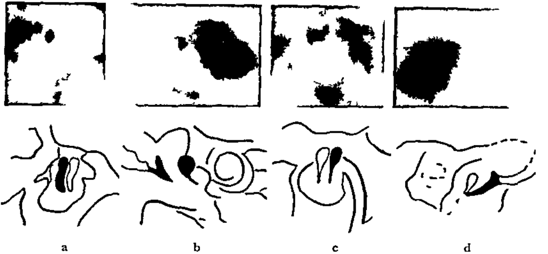


Fig 5 Case 2 Severe cranial trauma a) Right lateral Incus (black) and malleus rotated in close apposition b) Posterior Incus displaced medially relatively great distance from spur to incus c) and d) Normal left side lateral and posterior

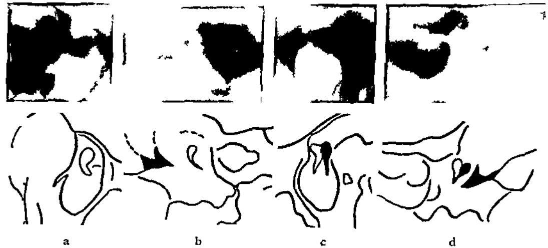


Fig 6 Case 3 Cranial trauma 15 years previously a) Right lateral Only the malleus visible incus absent b) Posterior Malleus displaced medially relatively great distance from spur (black) c) and d) Normal left side lateral and posterior

Case 3 Male aged 39 years who 15 years previously had fallen downstairs was unconscious for two days and had afterwards had marked loss of hearing on right side he was admitted suffering from epilepsy Operation showed medial displacement of the malleus with absence of the incus (Fig 6)

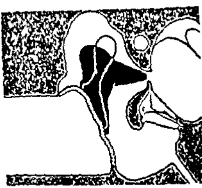


Fig 7 Columellar effect of incus stapes removed Incus re introduced into middle ear with its short process in oval window niche and its long process connected to the tympanic membrane malleus intact (after HALL & RYTZNER)

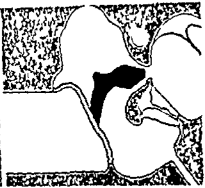


Fig 8 Columellar effect of malleus Incus and stapes removed and malleus re introduced into middle ear with its specially shaped head in oval window niche (after HALL & RYTZNER)

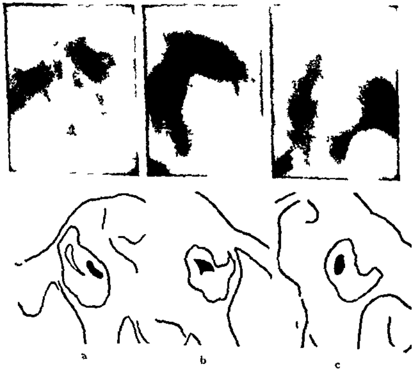


Fig 9 Appearances after columellar operations in three cases Malleus intact normal incudo-malleal joint not seen incus (black) displaced posteriorly and centrally a) Right lateral cut at 6 1 cm b) Left lateral cut at 2 9 cm c) Left lateral cut at 4 9 cm

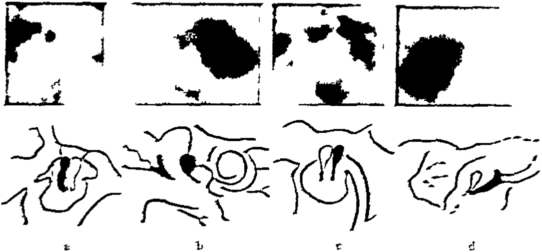


Fig. 5. Case 2. Severe cranial trauma. a. Right lateral. Incus (black) and malleus rotated in close apposition. b. Posterior. Incus displaced medially, relatively great distance from spur (arrow). c and d. Normal left side, lateral and posterior.

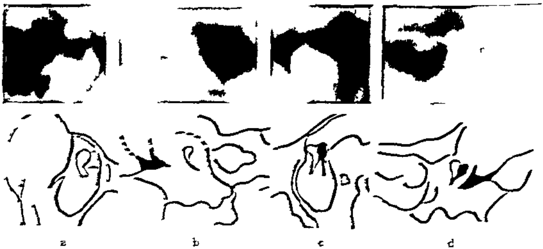


Fig. 6. Case 3. Cranial trauma 15 years previously. a. Right lateral. Only the malleus is seen, incus absent. b. Posterior. Malleus displaced medially, relatively great distance from spur (black). c and d. Normal left side, lateral and posterior.

Case 3. A man aged 34 years, who 15 years previously had fallen downstairs, was unconscious for two days, and had afterwards had marked loss of hearing on the right side. He was admitted suffering from epilepsy. Operation showed medial displacement of the malleus with absence of the incus (Fig. 6).

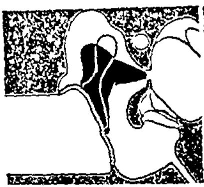


Fig 7 Columellar effect of incus, stapes removed Incus re introduced into middle ear with its short process in oval window niche and its long process connected to the t mpanic membrane malleus intact (after HALL & RYTZNER)

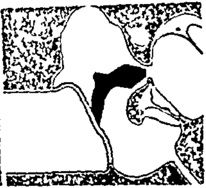
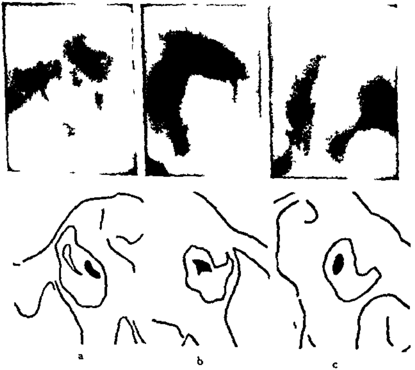


Fig 8 Columellar effect of malleus In cus and stapes removed and malleus re introduced into middle ear with its specially shaped head in oval window niche (after HALL & RYTZNER



Fi 9 Appearances after columellar operations in three cases Malleus intact, normal incudo-malleal jo nt not seen incus (black) displaced posteriorly and cen trall a) Right lateral cut at 6 1 cm b) Left lateral cut at 2 9 cm c Left lateral, cut at 2 9 cm

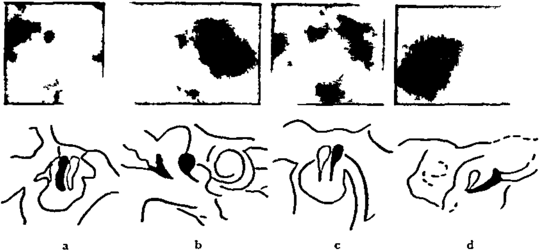


Fig 5 Case 2 Severe cranial trauma a) Right lateral. Incus (black) and malleus rotated in close apposition b) Posterior Incus displaced medially relatively great distance from spur to incus. c) and d) Normal left side lateral and posterior

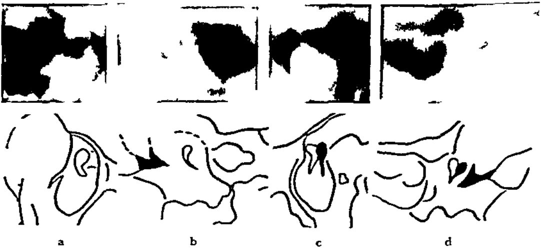


Fig 6 Case 3 Cranial trauma 15 years previously a) Right lateral. Only the malleus visible incus absent. b Posterior Malleus displaced medially relatively great distance from spur (black) c) and d Normal left side, Lateral and posterior

Case 3 Male, aged 39 years, who 15 years previously had fallen downstairs, was unconscious for two days, and had afterwards had marked loss of hearing on right side he was admitted suffering from epilepsy Operation showed medial displacement of the malleus with absence of the incus (Fig 6

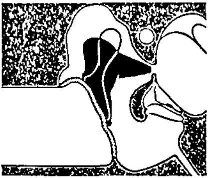


Fig 7 Columellar effect of incus stapes removed Incus re-introduced into middle ear with its short process in oval window niche and its long process connected to the tympanic membrane malleus intact (after Hall & Rytzner)

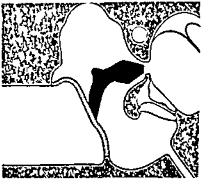
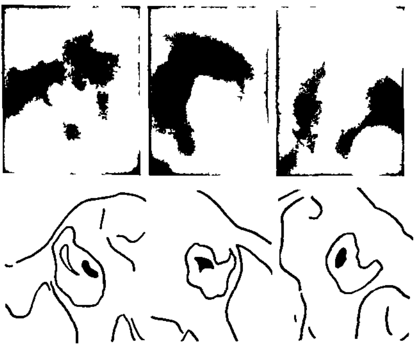


Fig 8 Columellar effect of malleus Incus and stapes removed and malleus re introduced into middle ear with its specially shaped head in oval window niche (after Hall & Rytzner)



a b c

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A few examples of the so called columella operation are illustrated in the following, and some case reports are presented In any attempted mobilisation of the stapes the crura may easily be fractured As, however, an unbroken ossicular chain is required for an optimal improvement in hearing, this chain must be re established (HALL and RYTZNER 1958) This requirement can be fulfilled by the columella operation After an unsuccessful mobilization of the stapes, its fractured crura are removed, and a fenestra is created in the foot plate of the stapes The incus is then extracted and at once re implanted with its short or long process in the fenestra, the tympanic membrane is folded back against the other process or the body of the incus, while the malleus is left intact In this way a new bridge, a columella, is established, across which the vibrations of the tympanic membrane are transmitted to the internal ear (Fig 7) In certain cases, in which the incus has been destroyed, a columella may be formed by the malleus, the specially shaped head of which is then placed in the fenestra (Fig 8)

Case 4 Female aged 18 who for the previous 8 years had suffered from marked loss of hearing Operation showed that the footplate of the stapes was fixed an attempt at mobilization of the stapes produced immediate fracture of the crura The incus was therefore extracted and re implanted with the long process in the fenestra (Fig 9a)

Case 5 Male aged 57 who for the previous 37 years had suffered from severe loss of hearing on both sides Operation revealed that the footplate of the stapes on the left side was stone hard and immovable The footplate was fenestrated and the incus extracted and re implanted (Fig 9b)

Case 6 Male aged 33 who had earlier undergone an unsuccessful Rosen -operation for otosclerosis Further operation disclosed a fractured neck of the stapes This was removed and the incus extracted and re implanted with its long process in the fenestra (Fig 9c)

Conclusion

Tomography of the middle ear with the polytome, and with hypocycloid movements and the skull in a p and lateral positions, with intervals of 2 mm and 1 mm, respectively, between the sections, provides optimal conditions for accurate definition of the finer details of the temporal bone The information thus obtained is of paramount importance in many affections of the middle ear and above all is a prerequisite in modern surgical procedures on the auditory ossicles

SUMMARY

A technique of tomography of the middle ear is described The method is of special value for demonstrating cholesteatomae labyrinthine fistulae and inter-ossicular dislocations

ZUSAMMENFASSUNG

Eine Tomographietechnik des Mittelohres wird beschrieben. Die Methode ist von besonderem Wert für den Nachweis von Cholesteatomen, Labyrinthfisteln und interossikulären Verschiebungen.

RÉSUMÉ

Description d'une technique de tomographie de l'oreille moyenne. Cette méthode est particulièrement utile pour mettre en évidence les cholestéatomes, les fistules labyrinthiques et les luxations inter-ossiculaires.

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FROM ROENTGEN DEPARTMENT II (DIRECTOR DOCENT I WICKBOM), SAHLGRENSKA SJUKHUSET, GOTHENBURG, SWEDEN

APPEARANCE OF SELLA TURCICA FOLLOWING TRANSSPHENOIDAL HYPOPHYSECTOMY

by

CLAES RADBERG

It appears that recalcification of the sellar region following surgical or radiation therapy of sellar tumours is rare and that the number of cases in which the size of the sella has tended towards normal limits is extremely small

HOLM (1943) could find only seven previously described cases of what he called signs of healing in the sellar region, all these cases received only radiation therapy, and had not been operated upon HOLM himself had 8 cases with regression of sellar changes among 27 cases examined roentgenographically both before and after operation or irradiation HOLM s total material consisted of about 200 verified pituitary adenomas at Serafimerlasarettet (the greater part of OLIVECRONA s series, later published by BAKAY in 1950) All 8 cases were chromophobe adenomas, probably because the material mainly consisted of cases with tumours of that type Seven of these eight cases had received irradiation as well as surgery and one case was only irradiated Two presented evidence of reduced size of the sella and recalcification in the sellar region, in four only recalcification was observed and in two cases the appearance of intrasellar calcifications was interpreted as a sign of healing

HENDERSON (1938) in his account of CUSHING s series of 338 cases of verified pituitary adenoma, mentions that SOSMAN observed that the sella had become small and had recalcified after operation However data concerning the

number of cases and illustrations of the sellar changes are not published Since the publication by HOLM, only occasional cases have been reported, mainly by American authors

The following authors described not only recalcification but also regression of the sellar dimensions after radiation therapy HURXTHAL et coll made repeated roentgen examinations of the sella after treatment in 14 cases in a material of 29 cases of acromegaly, in eight cases they noted regression of the sellar dimensions and recalcification was noted in some cases without any demonstrable change in size of the sella JOHNSEN reported regression of sellar size in three cases and recalcification in three others out of a series of 23 irradiated acromegalics UNGER & ROSWIT noted evidence of sellar reconstruction in four out of 70 cases irradiated for pituitary adenoma One of these, a case of acromegaly which developed marked regression of sellar enlargement after irradiation, had been earlier published by ADLER & KAPLAN Of the remaining three cases two of chromophobe and one of eosinophilic adenoma, all developed increased calcium content in the sellar region and one possibly some regression of the sella dimensions

A single case of regression of the sellar dimensions was published by GRAY & NEWELL in which a pituitary tumour was treated with radiation and extract from the thyroid and hypophysis Another case, reported by POSNER, was of a man with chromophobe adenoma treated with testosterone propionate and irradiation HIRSCH noted regression in the size of the sella after a transsphenoidal operation for craniopharyngeoma in a three and a half year old child

DYKE & DAVIDOFF described re ossification but no regression in size of the sella in any case following radiation therapy over a ten year period CAMP reported recalcification of the sella after operation and roentgen therapy of a chromophobe adenoma And finally, BACKMAN & HARRIS pointed out that in none of their 64 irradiated cases of pituitary adenoma had they seen an enlarged sella decrease in size or evidence of recalcification in demineralized clinoid processes The number of cases in which regression of changes in the sellar region has been proved is thus small

These publications in the main contain little about the roentgen findings and when details of the examination are included the investigations [illegible] seem incomplete In the majority of publications the sella has been evaluated with lateral projections only, and tomography has as a rule not been used An estimation of the size and shape of the sella is therefore uncertain, [illegible] those few cases in which it is possible to form an opinion from the illu[illegible] the accompanying interpretation is not always convincing The publ[illegible] by UNGER & ROSWIT in particular has neglected the fact that in large [illegible] adenomas the central part of the sella is disproportionately enlarged [illegible] lateral parts on one or both sides are considerably less affected [illegible] state that the sella in one of their cases was unchanged or dimi[illegible] on the basis of lateral measurements But from their illustratio[illegible]

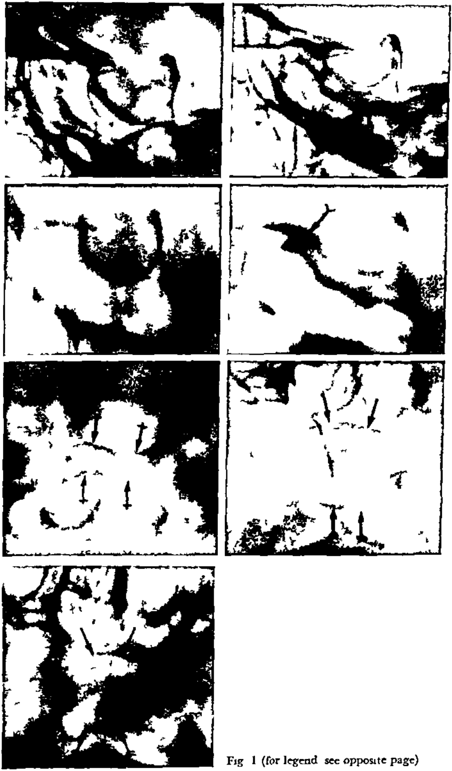


Fig 1 (for legend see opposite page)

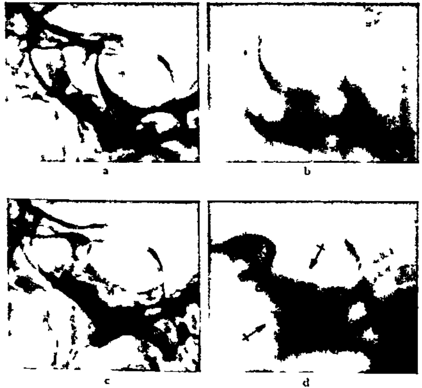


Fig 2 Eosinophilic adenoma Lateral roentgenogram (a) and tomogram (linear) (b) before operation c) Lateral roentgenogram 36 months after operation Decreased dimensions of sella especially in depth dorsum somewhat increased in thickness d) Lateral tomogram (polytome) through middle of sella Large operation defect (→) filled with dense tissue (↔) protruding into th sella as well as into the sphenoidal sinus, mainly causing decreased depth of the former marked increase in thickness of bone of presellar area but much less of remaining parts of the floor (Endocrinologic examination indicated complete removal of hypophysis.)

Legend to Fig 1 Eosinophilic adenoma *In upper row* lateral views before (l ft and 3 months after (right) transantrosphenoidal hypophysectomy Sella is shallower and somewhat shorter increased thickness of the bony walls and recalcification of the sellar region A th n calcification betw een left anterior and posterior clinoid processes *Middle row* lateral tomogram (l near) (left) before operation and (polytome) afte operation lateral to operation defect (r ght) Increased thickness of the sellar walls the recalcification of posterior part of the presellar area (→) and of th tuberculum sellae clearly shown *Bottom row* left frontal tomogram (polytome) through posterior part of floor (↔) dorsal to operation defect reveals increased thickness of floor in the frontal plane Calcification (↔) between left cl no d processes *Bottom r w* (right) and single view (to the left) axial roentgenograms, before and after operation The anterior wall (→) has a more normal trans erse course following operation than before when t lay obliquely Distance between the anterior wall and dorsum (»→) diminished posterior clinoid processes recalcified (Endocrinologic examination indicated that removal of the hypophysis was complete)

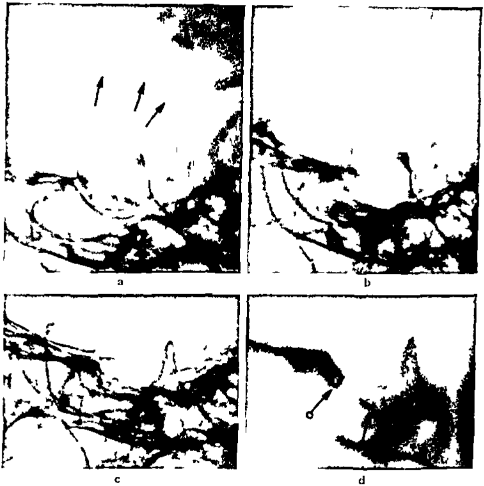
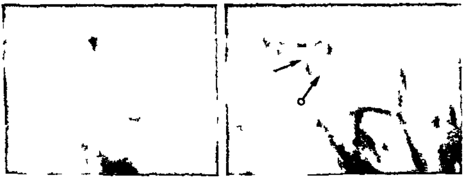


Fig 3 Craniopharyngeoma partly intrasellar a) Encephalography lateral supine Thin walled sella containing nodular calcifications large suprasellar extension of tumour causes upward displacement of anterior part of third ventricle (→) and displacement of suprasellar cisterns b) Encephalography 8 days after operation No evidence of suprasellar extension of tumour lower part of third ventricle lies close to top of dorsum intrasellar calcifications are no longer present density evident in sphenoidal sinus defect in anterior wall of sella is not clearly seen c) Lateral roentgenogram 41 months after operation *Marked increase in thickness of bony walls of sella which is shallow but not shorter the* sellar entrance is however wider than before operation due to a more erect position of dorsum d) Lateral tomogram (polytome) Defect (o→) in anterior wall and increased thickness of bony walls of sella density evident in sphenoidal sinus and in defect (Partial panhypopituitarism developed after operation)

that the central part of the sella, corresponding to the region of greater volume, has in all probability increased in size

Material and Methods

All cases described in the present paper were treated surgically by the transantrosphenoidal approach devised by HAMBERGER & NORLEN The aim



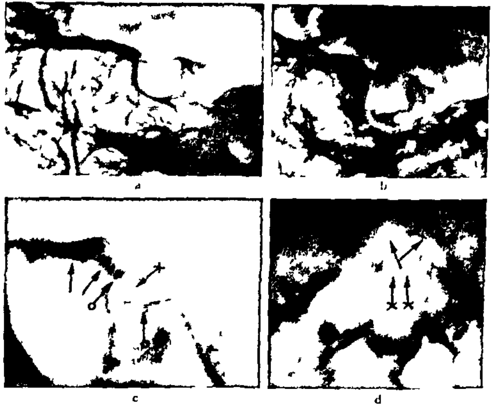
a b

Fig 4 Eosinophilic adenoma a) Lateral tomogram (linear) Total decalcification of tuberculum sellae presellar area and upper part of dorsum. b) Lateral tomogram (linear) as in (a) in the midline 28 months after operation At least partial restoration of contour of presellar area and formation of new bone (→) in this region and under posterior part of sphenoidal plane recalcification of dorsum has occurred the sella has somewhat smaller dimensions operation defect (⊸) in anterior wall and floor (Pituitary insufficiency did not develop after operation)

has been complete removal of the tumour or of the hypophysis and radical removal has as a rule been accomplished Hypopituitarism, developing after total hypophysectomy can be controlled by means of a simple substitution therapy, as shown by LUFT et coll in 1951 None of the cases received irradiation of the sellar region postoperatively Some of the cases were irradiated a long time before operation but the therapy was without apparent effect upon the signs

During the period 1955—1960 163 cases were operated upon according to this method Tumours in the sellar region were removed in 37 cases, and in the remaining 126 cases a normal hypophysis was extirpated in order to achieve a hormonal effect on various conditions of disease All these 163 cases were examined roentgenographically before operation, and 21 cases were investigated in a corresponding manner at various times after operation The pre and postoperative roentgen examination included in almost every case roentgenograms of the whole skull as well as coned down views of the sella in lateral, axial and frontal projections Some of the lateral and axial roentgenograms were so angled that they could be viewed stereoscopically The sellar region was examined by tomography in the majority of cases the tomograms being obtained in a p , lateral and sometimes in axial projections Only tomographic apparatus with linear blurring was used during the earlier part of this investigation but a polytome subsequently became available

Cases of sellar tumours A follow up examination was performed between two months and three and a half years after the operation in 6 of the 37 tumour cases Preoperatively the sella was changed by an intrasellar tumour in all six cases (4 cases of eosinophilic adenoma 1 of chromophobe adenoma and 1 case



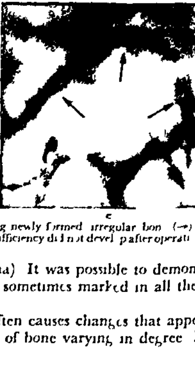


Fig. [illegible] Mammary carcinoma a) Normal appearance of sella before operation b) Lateral roentgenogram 20 months after operation Antero inferior part of sella somewhat more angular area of increased density evident in posterior and upper part of sphenoidal sinus bone in the sellar region somewhat decalcified c) Lateral tomogram (polytome) through middle part of sella Defect (↔) in anterior wall, clearly visible only in the tomograms filled with soft tissue (↔) continuing downwards into posterior part of the sphenoidal sinus new bone formation (→) under the sphenoidal plane and presellar area bounded with a cortical layer against the operation defect d) Frontal tomogram (polytome) at the level of the defect which above and laterally is surrounded by newly formed bone (→) below the operation defect is bounded by a soft tissue membrane (↔) e) Frontal tomogram (polytome) 4 mm ventral to the cut in (d) at the level of the sphenoid limbus showing newly formed irregular bone (→) on inner side of walls of sphenoidal sinus (Pituitary insufficiency did not develop after operation)

of a partially intrasellar craniopharyngeoma) It was possible to demonstrate regression of the sellar lesion and this was sometimes marked in all the control examinations

Increased pressure in the sellar region often causes changes that appear in the roentgenogram as apparent absorption of bone varying in degree If the

pressure is removed, the appearance of the bone in the sellar region again becomes fairly normal This would indicate that no real destruction but only decalcification of bone has occurred According to present conceptions of bone pathology however, removal of both the organic and inorganic components of bone occurs in one stage and there is no evidence of dissolution of calcium salts from the matrix of bone when fully developed (citation from MAHMOUD) The current terms in the roentgenologic literature are, however decalcification and recalcification and these are used in this paper

The regressive changes observed by the writer in these six cases were as follows

1 Decreased size of the sella turcica in all cases investigated The sella has almost always become shallower and, to a lesser extent shorter (Figs 1 and 2)

2 Recalcification of the sella in all cases

3 Increased thickness of the dorsum (with recalcification of the decalcified dorsum) and posterior clinoid processes in all cases investigated The dorsum had a more erect appearance in a few cases on control studies (Fig 3) and was most marked in cases of craniopharyngeoma A possible explanation could be a downward displacement of the third ventricle and surrounding tissue in the absence of the hypophysis and sometimes of the diaphragma sellae as well

4 Increased thickness of the remaining parts of the anterior wall and floor of the sella (Figs 1 and 3) The floor was visible both before and after operation in 3 cases and a marked increase in its thickness was observed The floor was not visible before or after the operation in the remaining 3 cases and could not be assessed In one case (chromophobe adenoma) the floor before operation was totally decalcified but was partially restored eleven months following the operation In another case there was no pneumatization of the body of the sphenoid beneath the sellar floor In a third case it was not possible to distinguish the bony part of the floor because of markedly increased density of the sphenoidal sinus following the operation

5 Restoration of the chiasmatic sulcus (presellar area, according to ZANDER) and of the tuberculum sellae (Fig 4) There was more or less advanced decalcification of the presellar area and an acute angle between the remaining part of the presellar area and the anterior wall in all cases except the case with chraniopharyngeoma The presellar area following operation regained a fairly normal contour Judging from these observations the changes observed before operation in the presellar area seem to be highly suggestive of an intrasellar tumour

6 Recalcification of the bony bridge between the optic foramen and the superior orbital fissure an area which is often decalcified in sellar tumours encroaching far ventrally Recalcification of this structure was evident following operation in the case of a chromophobe adenoma

Intrasellar calcifications observed by HOLM and considered by him to be a



a b



c

Fig 6 Normal hypophysis was removed for hormonal influence for severe diabetes a) Lateral roentgenogram before operation Normal appearance of sella b) Lateral roentgenogram 21 months after operation No apparent change in shape of sella narrow area of density in upper and posterior parts of sphenoidal sinus not present before operation c) Lateral tomogram (polytome) through middle part of sella The tomogram alone reveals clearly the defect in the anterior wall and membrane (↣) of the defect which in this case measures about 7 mm and partly fills in the antero inferior part of the sella thickening of bone (→) under presellar area and posterior part of sphenoidal plane

sign of healing have not been noted in this material It is very doubtful whether the development of intrasellar calcifications can in fact be considered a sign of healing It would appear to the present writer that it is more probable that calcifications lie in haematomas or remnants of the adenoma

Cases of normal hypophysis and sella A roentgenologic control examination was performed at an interval ranging between one month and 28 months after the operation in 15 of the 126 cases

As in the tumour group, the defect in the anterior wall of the sella was visible following operation but was well defined only with tomography It appeared to remain more or less unchanged in size during the observation time A tissue of higher density than the surrounding soft parts, and of somewhat lower density than the surrounding bone, and which forms a kind of membrane of rather variable thickness is always present in the defect Tissue of similar density is often encountered in the adjacent parts of the sphenoidal sinus It is sometimes also possible to demonstrate extension of the membrane tissue into the basal parts of the sella (Figs 2 and 6) In such cases and in those cases in which the membrane had a straight course in the defect, the sella had a smaller volume than before the operation (Fig 7) In other cases the



a b

Fig 7 Mammary carcinoma a) Lateral tomogram (linear) through middle part of sella before operation Normal appearance of sella small distance (+) between the sphenoidal limbus and the presellar area bony septum (⟶) in the sphenoidal sinus b) Lateral tomogram (polytome) through middle part of sella seven months after operation operation defect comprises almost the whole floor and lower half of anterior wall membrane (⟷) 2 to 3 mm thick in the defect running a straight course (If this membrane is considered to be the new boundary of the sella antero-inferiorly the latter after operation is somewhat smaller) Sclerotic thickening of bone (→) in posterior part of sphenoidal plane and in the presellar area The distance between the sphenoidal limbus and presellar area which was visible before operation is now filled up with bone There is soft tissue of the same nature as in the defect immediately under the sclerotic bone bony septum no longer present (Complete panhypopituitarism developed after operation)

membrane had a concave sellar surface and the sella could then be considered to be of the same or somewhat larger size (Fig 5) If this membrane in the operative defect is therefore considered to represent the anterior wall of the sella it seems that the sella often changes shape postoperatively At microscopy the soft tissue, according to the pathologist (Mr Knutsson), is seen to consist mainly of granulation tissue with a high proportion of collagen

Thickening of the bone in the region of the presellar area and the posterior part of the sphenoidal plane was evident fairly early after operation (Figs 5, 6 and 7) Similar changes also appeared in the walls of the posterior part of the sphenoidal sinuses This newly formed bone had a variable thickness, and a somewhat irregular structure and along the upper part of the defect was covered by a thin cortical layer (Figs 5 and 6) The reason for this formation of new bone is not obvious The changes are similar to those seen in the walls of a chronically inflamed sinus (Investigation of these changes with roentgen microscopy have as yet been performed only on a small scale and the final results of this investigation will be reported separately)

Discussion

Regression of sellar changes after irradiation or surgery of sellar tumours has been reported in earlier published material only in a rather small percentage of cases With due reservation for the small number regression has ap

peared in all the present cases The demonstrated difference in the frequency of regression may partly depend on the fact that the roentgen examination in the present series has been more complete than in the series published earlier It has been possible in the present series to make accurate evaluation of small changes in sellar size and wall thickness and to detect other minor changes, such as restoration of the presellar area, an observation not previously made The main reason for the difference in frequency of regressive changes is, however, presumably not due to the technique of the roentgen investigation but to a real difference in the regressive changes that has occurred This has been brought about by the fact that the cases have all been subjected to radical removal of sellar tumours Complete removal was intentionally avoided in earlier operative series because of the danger of postoperative panhypopituitarism which could not be managed at that time

Exactly when the regressive phenomena appear cannot of course be determined with precision without frequent roentgenograms It was not possible to see definite signs of regression as early as two months after operation but after eleven months distinct evidence of regressive changes had appeared in several cases

It is known from previous observations that the sella again will decalcify and possibly enlarge when there is recurrence of a sellar tumour (CAMP) A case of recurrence has not yet been observed in this series The lesions caused by a recurrent tumour will, however, perhaps present another roentgenologic appearance, with absence of parts of the sellar floor permitting at least a portion of the recurrent tumour to grow down into the sphenoidal sinus A new roentgenologic sign of recurrence may then be that the membrane developing postoperatively in the surgical defect of the floor of the sella may take another course and possibly bulge down into the sphenoidal sinus This sign will be detectable only with the aid of tomography

The changes occurring in the sella and sphenoidal sinus after removal of a normal hypophysis have been investigated and reported so as to have a control group for comparison with the tumour cases and also because a series of cases with these changes, investigated in the manner described has not previously been published It must be stressed that in both the tumour group and in the group with normal sellae, the series is too small and the observation time too short to permit definite conclusions

SUMMARY

Six cases of different types of tumours in the sellar region that were examined roentgenographically with special reference to the degree of calcification of the sella before and at various times after transantrosphenoidal hypophysectomy are described Fifteen normal cases in which hypophysectomy was performed for hormonal effect served as controls

ZUSAMMENFASSUNG

Der Knochengehalt der Sella wurde in 6 verschiedenen Fällen von Tumor vor und nach Entfernung der Hypophyse auf operativem Weg durch Antrum und Keilbein untersucht. Das Resultat wurde mit 15 normalen Fällen verglichen in denen die Hypophyse lediglich für den hormonalen Effekt reseziert wurde.

RÉSUMÉ

L'auteur présente six cas de tumeurs de types différents de la region sellaire qui ont été examinés radiographiquement avant et à divers intervalles après hypophysectomie transsphenoidale pour étudier le degré de calcification de la selle. Quinze cas normaux ou l'hypophysectomie a été faite pour son effet hormonal ont servi de cas temoins.

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FROM ROENTGEN DEPARTMENT II (DIRECTOR DOCENT I WICKBOM) SAHLGRENSKA SJUKHUSET, GOTHENBURG, SWEDEN

SOME ASPECTS OF THE ASYMMETRIC ENLARGEMENT OF SELLA TURCICA

by

CLAES RÅDBERG

An ordinary lateral view of the sella turcica will usually demonstrate whether it is enlarged although asymmetric enlargement may easily be overlooked The anterior wall and floor of the sella, on account of their shape and extension forwards, may produce several antero inferior convex outlines This appearance is often called a double floor (even if more than two outlines are present) A double floor formation in a true lateral view is considered evidence of asymmetry of the sellar floor but there are exceptions The sellar floor may even in normal cases be markedly convex downwards in the frontal plane, and in such cases a double floor may be apparent, even if the sella is symmetric, if the roentgen beam is tangential to different parts of the floor (Fig 1) There are also, in the immediate neighbourhood of the floor, structures, such as the carotid sulcus, septa and walls of the sphenoid sinus that may have contours parallel to it and produce a false appearance of a double floor (Fig 2)

The absence of signs of a double floor does not, however rule out asymmetry or asymmetric enlargement A single contour of the floor may imply that a part of the latter is of such a shape that it is not struck tangentially by the beam and consequently is not depicted in the lateral view (Fig 3) A high degree of decalcification may also be another reason for the asymmetric part of the floor not being shown MAYER in some cases of asymmetric sellar enlargement with

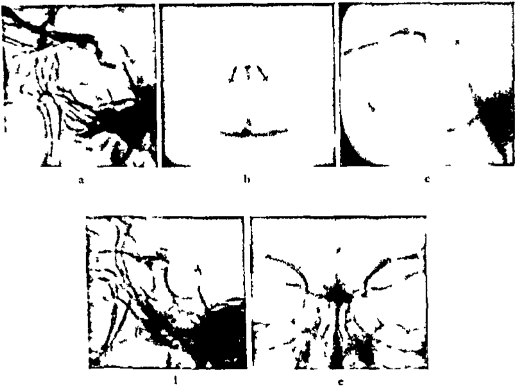


Fig 1 Two symmetric types of sellae with double floor formation due to downward convexity of the floor a) The whole floor of the sella demarcated against the air in the large sphenoidal sinuses b) Frontal tomogram through the V shaped floor (→) of sella c) Lateral tomogram through the middle and deepest part of the sella in (a) d) Lateral parts of sellar floor ill-defined due to absence of underlying air and their asymmetry with the plane of the beam e) Downward convexity of the floor (→) in the frontal roentgenogram

total decalcification of the sellar floor, in which apparently only lateral views were obtained, has interpreted the anterior part of the carotid sulcus as the 'lower root of the anterior clinoid process and the posterior part as 'the displaced floor of the sella The lateral tomograms in Fig 2, d and e, may offer an explanation for this misinterpretation

It is therefore sometimes impossible with only a single lateral conventional view or even with lateral tomograms to decide whether part of a double floor contour is real or is caused by surrounding structures The possibility of the presence of asymmetry, especially marked asymmetric enlargement also cannot be eliminated Oblique lateral projections and a stereoscopic technique may be of some additional help to differentiate the structures in the lateral view and still more information may be gained by tomography Conventional and tomographic a p , axial and oblique projections however are also

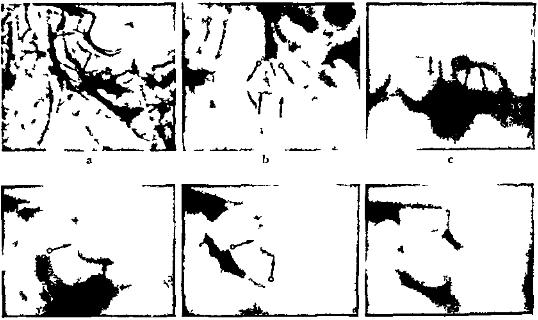
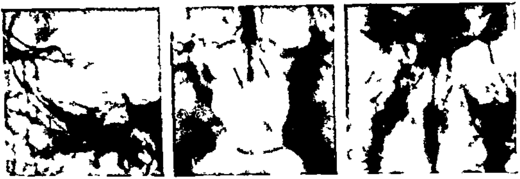


Fig 2 a) Lateral view Carotid sulcus simulating asymmetric sellar enlargement thin cortical contour (→) running parallel to anterior wall and floor of sella simulating an enlarged part of an asymmetric sella b) Axial view Anterior wall (→) and carotid sulci (→) normal and symmetric. c) Frontal tomogram Narrow and level sellar floor (↔) rather deep repression (→) representing posterior part of left carotid sulcus immediately to the left of sellar floor no obvious depression of the right carotid sulcus d) and e) Lateral tomograms through medial and lateral parts of left carotid sulcus (→) f) through middle part of sella

required for a satisfactory delineation of the sellar dimensions from these views the volume of the sella turcica may also be estimated

There are great variations in the normal width of the sella According to anatomical investigations of Karlas, based on 171 specimens the width of the middle part of the sellar floor may vary between 6 5 to 16 5 mm a normal variation of 10 mm and the width of the upper part of the anterior wall between 5 5 to 14 mm, a variation of 8 5 mm A sella which in the lateral view is apparently large may actually be narrow (Fig 4) Again a small sella in the lateral view may be broad and the total size within normal limits (Fig 5) Even sellas that in lateral views appear normal may be very narrow or very broad and their sizes within the pathologic range

The above considerations may serve as a general outline in judging sellar size The diagnosis of sellar conditions and pituitary disease based on the size of the sella and in the absence of other structural change is difficult and uncertain (Camp) The uncertainty is further increased by the fact that there is no constant relationship between the size of the sella and the size of the hypophysis (Rasmussen Bokelmann) The determination of the width of the



a b c



d

Fig. 3. Asymmetric enlargement of sella evident in axial and frontal views but not in lateral view. Chromophobe adenoma with parasellar and suprasellar extension on left side. a) Lateral view. The enlarged part of the sella is not in the same plane as the beam. b) Axial view. Oblique anterior wall (→). c) Frontal view. Sellar floor (↔) markedly oblique. d) Frontal tomogram confirms position of the sellar floor (↔).

sella is therefore of greater value in judging its shape than its volume. It must be stressed, however, that, in determining possible enlargement of the sella, consideration must be given to the length and depth as well as to the width, rather than to calculations based on the lateral projection alone (Di Chiro).

The need for roentgenologic estimation of the width of the sella has been mentioned only by very few authors. Haas (1927) and Farinas (1939) suggested semi-axial projections for demonstration of the dorsum sellae and the width of the sella. These projections, however, produce distortion and are of limited value in estimating the size of the sella, a limitation that has been pointed out by Mahmoud. Several Italian authors, Meldolesi & Passadoro (1937), Ottaviani (1938), Cardillo & Bossi (1941) and Anzilotti (1952) have published attempts at determining the volume of the sella from the width. Tomography in the frontal projection of the sellar floor was used by Cardillo & Bossi. Di Chiro (1960) observed that the floor of the sella appears in 90 % of p.a. views of the skull, and in the remaining 10 % may be demonstrated with the aid of tomography in the frontal projection. The floor of the sella shows up clearly in this projection if the sphenoidal sinuses extend posteriorly beneath the sellar floor, and if they are gas filled. If the sinuses do not extend so far posteriorly, the floor may still be visible if its cortical lining is thick and dense and the projection is well chosen. Hammer & Radberg found in a



a b c

Fig 4 Sella large in the lateral view but small in width no clinical signs of pituitary disease a) Lateral view Length of sella (anterior wall—ventral aspect of dorsum) in original film 16 mm depth 12 mm b) Axial view Extremely narrow anterior wall (7 mm) (→) anterior part of carotid sulci (→) clearly visible local thickening of bone at attachment of intersinusal septum in medial part of right carotid sulcus c) Frontal view The narrow floor (↔) measures about 8 mm

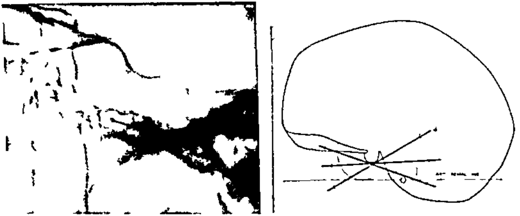


a b c

Fig 5 Sella small but of considerable width in lateral view no clinical signs of pituitary disease a) Lateral view Both the length and the depth of sella about 7 mm b) Axial view Upper part of anterior wall (→) unusually broad and measuring about 19 mm symmetric forward convexity within normal limits small carotid sulci (→) c) Frontal view Rather broad floor (↔) measuring about 13 mm

series of 120 specimens that the sphenoidal sinus extended beneath the floor of the sella, at least on one side, in 86 % This figure is in close accordance with that of Di Chiro s

Angulation of the tube 5 to 10 degrees cranial to the orbito meatal line in the p a projection generally demonstrates the sellar floor When the floor of the sella is rounded it is usually possible to demonstrate its different parts by changing the angulation of the tube, an increase in the angle shows the posterior parts better, while a reduction produces better anterior detail (Fig 6) A level floor necessitates the central beam being parallel to it The correct projection is determined with the aid of the lateral view



a b



c d e

Fig 6 a) Lateral view of normal sella b) Schematic illustration of the parts of the sellar floor that are projected in the three subsequent p a projections for demonstrating the appearances of the sellar floor in different craniocaudal angulations of the tube c) Angulation of tube 5 cranial to orbitomeatal line middle of floor shown d) Angulation 25 cranially Posterior part of floor depicted e) Angulation 20 caudally Sellar floor projected into upper part of the frontal sinus anterior part of the floor demonstrated

If the floor of the sella cannot be defined in spite of every effort to obtain a suitable projection, tomography, preferably with pluridimensional blurring at least for the frontal views, must be performed The superimposed structures in this region the ethmoid cells, nasal septum medial parts of orbits can seldom be entirely eliminated by linear blurring and invariably coincide to some degree with the movement of the tube, irrespective of the patient s position We usually employ a polytome Thin cuts are essential for a detailed analysis of the different parts of the floor of the sella The usual points of orientation are blurred by tomography and careful attention must consequently be paid to the precise level of the cuts



a b

Fig 7 Roentgenograms of preparation of sphenoid bone The pituitary gland is visible as a soft tissue density between the calcified carotids a) Frontal projection Floor (↔) of sella practically level indistinct demarcation of floor against lateral slope of carotid grooves(→) b) Axial projection Boundary between anterior wall (→) and carotid sulci (→) fairly clearly outlined determination of sellar width therefore more accurate in axial than in frontal view width of anterior wall corresponds to that of the pituitary gland

FISCHGOLD et coll have made extensive use of linear tomography in the analysis of normal and pathological sellae These authors state that the floor may be convex as well as level or concave However, the tomogram published, illustrating an upward convexity of the sellar floor, probably represented a cut through the presellar area or chiasmatic sulcus (cf ZANDER), which is often convex upwards An error in interpretation appears probable since in a sub mentovertical view in the same paper the anterior wall of the sphenoidal sinus is labelled by the authors as the tuberculum sellae and the anterior wall of the sella as the dorsum sellae (FISCHGOLD & METZGER 1953) OTTERSKY found no example of upward convexity of the sellar floor in 55 preparations of the sphenoid bone, and KARLAS observed only two examples among 171 specimens This shape of sellar floor would therefore appear to be rare

The floor of the sella is not solely responsible for the third dimension of the sella Consideration must also be given to the anterior sellar wall, the width and course of which vary independently of the floor and dorsum The im portance and possibility of roentgenographically reproducing the course and width of the anterior sellar wall in the frontal plane has so far as the author is aware, not previously been reported

The upper part of the anterior wall of the sella especially the part consisting of compact bone, is demonstrated in an axial view provided the central beam coincides with a plane through the anterior wall It is usually possible to obtain such a projection excepting in those cases in which the anterior wall has a



a b

Fig 8 Appearances of anterior wall of sella (→) and anterior part of the carotid sulci (→) in axial projection in normal cases a) Anterior wall of medium width frontal lateral septum (↣) in right sphenoidal sinus immediately behind the right carotid sulcus b) Very narrow anterior wall and large carotid sulci

markedly sloping course, cases of the so-called 'flat sella The ability of the subject to extend the head is naturally of great importance in obtaining a suitable projection It is possible to demonstrate the anterior wall in an axial projection in almost 100 % of preparations

The lateral boundary of the anterior wall is marked by the most anterior part of the carotid sulcus ENGELS (1958) described the appearance of the carotid sulcus in lateral projections The most anterior part of the carotid sulcus may be defined bilaterally in axial views almost as often as the anterior wall of the sella and it appears as a thin anteromedial convex cortical layer of bone continuing posteriorly into the compact bone of the anterior wall of the sella turcica When in addition to the anterior wall the carotid grooves are also discernible in axial views the extent of the former in the frontal plane may be closely determined The boundary between the anterior wall and the carotid grooves is as a rule, clearly marked (Figs 7 and 8) although determination of the width of the floor is sometimes uncertain This is true at least when the floor is level and without any clear lateral demarcation continues into the lateral slope of the carotid grooves The level type of floor occurred in anatomical research according to OTTERSKY in 55 8 % and according to KARLAS in 34 5 % of specimens The carotid grooves in these specimens may easily be mistaken for parts of the sellar floor and the impression gained of an upward convexity of the floor (Figs 2c and 7a)

A review of more than 300 routine skull films confirmed that the width of the anterior wall could be determined in about 70 % it varied between 7 and 16 mm with the majority of the widths in the 10 to 12 mm range This correlates



a b

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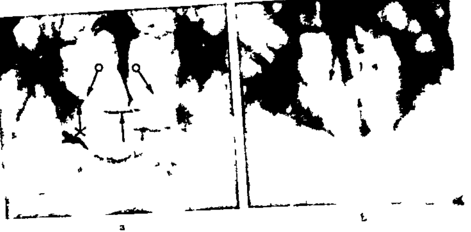


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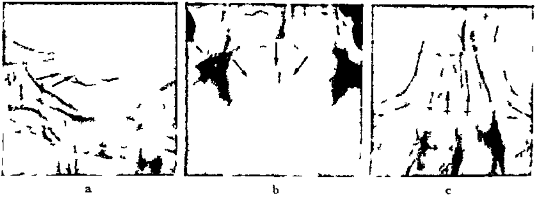
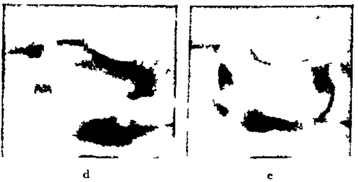


Fig 9 Asymmetric enlargement of sella evident only in the axial view (No operation endocrinology indicated a tumour of the hypophysis) a) Lateral view The most anterior part of the anterior wall (→) of similar appearance as the carotid sulci compare with the normal case in fig 10 b) Axial view Pathologic bulging of anterior wall (→) c) Frontal view Floor (↔) of sella appears normal d) and e) Lateral tomograms confirming the asymmetric enlargement of the sella



well with various anatomical investigations In 40 preparations of the sphenoid bone investigated both with axial and frontal projections, the width of the anterior wall and of the floor was the same in only 6 specimens The anterior wall was narrower than the floor, mostly by 1 to 4 mm and in a single case by 6 mm, in 24 preparations and the anterior wall was somewhat broader than the floor, mostly by only 1 to 2 mm, in 13 specimens There is therefore usually a difference in width between the upper part of the anterior wall and the floor that may often be as much as 20 to 25 % Assuming the volume of the hypophysis can be determined from that of the sella it would appear that the widths of the floor and anterior wall will together afford the best indication of sellar size

The anterior wall of the sella as seen in the axial view normally lies more or less in the frontal plane although small deviations of the anterior wall from the frontal plane and of the floor from the horizontal plane are often encountered Enlargement of the anterior part of the sella displaces the anterior wall forwards, often with a forward convexity (Fig 9) and if the carotid siphon is also displaced forwards by a slow growing tumour the carotid sulcus also will assume a more anterior position Asymmetric enlargement of the sella produces an oblique course of the anterior wall (Fig 11) When the anterior wall is



Fig 10 Normal case with large carotid sulci as compared to the case in fig 9 a) Lateral view Carotid sulci (→) of similar appearance as the anterior wall of the enlarged sella in fig 9 b) The anterior wall because of its sloping course is not visible in the axial projection Well-defined large carotid sulci (→)

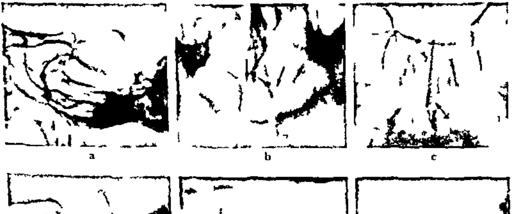


Fig 11 Asymmetric enlargement of sella in acromegaly no operation a) Lateral view The enlarged part of the sella may be misinterpreted as septa or wall of a recess of the sphenoidal sinus b) Axial view Oblique anterior wall (→) with several contours to the right due to marked bulging anteriorly c) Frontal view The floor (↔) is depressed especially in its middle and to the right d) and e) Lateral tomograms through the least and the most enlarged parts of the sella f) Frontal tomogram showing the position of the floor (↔)

pushed forwards by sellar enlargement it increases in width because the body of the sphenoid bone ventral to the anterior wall is also increased in width The same is true of the floor of the sella when depressed because the body of the sphenoid is also increased in width downwards

SUMMARY

The evaluation of the size of the sella turcica from a p , axial and the more common lateral projections is discussed The different dimensions of the sella are of importance esp cially in its asymmetric enlargement, and provide a better indication of its true size than those obtainable from lateral views alone Additional information may occasionally be gained from tomography

ZUSAMMENFASSUNG

Die Abschatzung der Grosse der Sella turcica wird unter Hinzuziehung der a p der axialen und der seitlichen Aufnahmen besprochen Alle Masse sind von Nutzen, besonders b i asymmetrischen Vergrosserungen und geben b ssere Resultate als die Messung der seitlich n Aufnahme allein Tomographie kann gelegentlich von Nutzen sein

RÉSUMÉ

L auteur étudie la mesure des dimensions de la selle turcique à partir des radiographies de face en incidence de la base et de profil Les diverses dimensions de la selle sont importantes en particulier quand elle est agrandie asymétriquement et renseignent mieux sur son véritable volume que les mesures faites à partir des seules radiographies de profil La tomographie fournit parfois des renseignements complémentaires

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CEREBRAL ANGIOGRAPHY BY CATHETERIZATION — COMPLICATIONS AND SIDE EFFECTS

by

PER AMUNDSEN, PER DIETRICHSON IVAR ENGE and ROLF WILLIAMSON

Since cerebral angiography was introduced for diagnostic purposes more than thirty years ago, its indications (e g KUHN, and WHISNANT), technique (ENGESET ELFVIN, LIVERUD, LINDGREN, inter al), contrast media (BROMAN, BROADBRIDGE, and ENGESET, inter al) and its complications (BAKER, BRENDLER, CODDON, LIVERUD, MARTINEZ, SCHOLTSEL, and WICKBOM inter al) have all been adequately covered in the literature The possibility of effective treatment in cerebral vascular disease has extended the field of indication for cerebral angiography and made it important carefully to consider the complications of the examination

The frequency of sequelae vary considerably in different publications from none (SEGELOV) up to 20 % (CODDON et coll) This discrepancy is probably due to several factors variations in the definition of complications and their evaluation, differences in planning of the investigations, difficulties in deciding which changes are caused by the angiography and which by the condition itself Furthermore, the series selected vary widely as to the type of cases included and, therefore are not strictly comparable It seems that most investigations dealing with complications in cerebral angiography have been based upon a retrospective analysis It may however be difficult in this way correctly to evaluate the physical condition of the case before and after angiography

Table 1

Number of angiographic examinations performed in a material of 803 cases

		Carotid	Vertebral	Total
Group A Period January—December 1960		620	96	716
Group B Period January—April 1961		233	22	255
	Totals	853	118	971

Our investigation was consequently planned to include a close observation of each case especially in regard to possible complications The clinicians examining and treating the cases in the wards were asked to follow each one and to complete a record card for each examination This control was applied to all cases examined during 1960 and represent group A of the present material (Table 1)

Even this system however, appeared unsatisfactory since the cases were referred from several different sources During the first 4 months of 1961 each case therefore underwent a brief neurologic examination in the roentgen department before and one hour after the main examination to detect whether any change had occurred In addition a complete neurologic examination was carried out the next day These cases represent group B of the material (Table 1)

The 971 angiographic examinations were performed in 803 cases of which 110 cases were examined twice and 34 cases three times I case being examined as many as 5 times Bilateral examinations at the same session were performed in 5 cases and are recorded as a single examination The first examination was unsatisfactory in 18 cases and 17 of these were re examined successfully

The age distribution (Fig 1) shows that in more than half the cases the subject was 50 years old or over In the B group the greatest number of sub jects were in their sixties This probably indicates a tendency to receive for examination more and more middle aged and elderly subjects and their num ber is a consequence of the groups of disease investigated (Fig 2 and Table 2)

Nearly half the examinations were performed in cases of cerebral vascular disease The relatively smaller number of cases classified as miscellaneous in group B as compared to group A, indicates the detailed evaluation of the cases in the former group

The condition of the subject must of course be expected to influence the rate of complications, even desperately ill patients had been accepted for examination in this series

Another factor influencing the risk of complications in cerebral angiography is undoubtedly the technique adopted One reason for presenting this paper

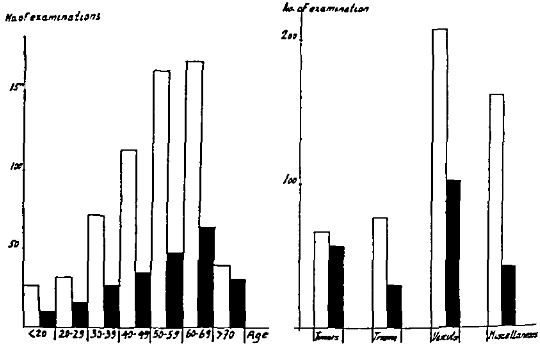


Fig 1 Age distribution in 803 cases in which 971 angiographic examinations were performed. Fig 2 Distribution of the various groups of disease in the material examined
White columns = group A. Black columns = group B

is that the standard technique which has been applied in our department for more than six years is one that is not commonly used in other centres The main point is that percutaneous catheterization of the common carotid artery is performed by the Seldinger technique, and that catheterization of the vertebral artery via the brachial or the femoral artery, is used in vertebral angiography It must be stressed that a careful and gentle puncture with a very sharp needle is considered particularly important and the aim is to puncture only the anterior wall of the artery The radiologist is not allowed to start with carotid angiographies until he has completed a training period of percutaneous catheterization mainly of the femoral artery

Two different contrast media were used alternatively during the group B period one being Hypaque 45 % (sodium diatrizoate) in 129 examinations the other a new compound called Isopaque 45 % (sodium N methyl 3, 5 diacetamido-2,3 6, tri iodobenzoate) in 115 examinations No evidence of differences in side effects could be detected in these two groups

Our analysis of the group A cases clearly indicated the difficulty in evaluating the relationship between the angiographic findings and changes in symptoms and signs before and after the examination It will generally be hard to draw definite conclusions in spite of a thorough follow up system, as was maintained in the group B cases

Table 2

Number of cases and angiographic findings in different groups of disease in a total

Pathologic process	Group A	Group B	Total	Angiographic findings
Tumour	67	57	124	Expanding process Negative
Trauma	79	30	109	Extracerebral haematoma and/or expanding intra cerebral process Negative
Vascular	209	103	212	Arterial occlusion (complete or subtotal) extra or intra cranial Expanding process Aneurysm arteriovenous anomaly Negative
Other	163	43	206	Positive Negative
Totals	518	233	751	

Renewed bleeding frequently occurs spontaneously in cases [illegible] aneurysms and arteriovenous anomalies during a stay in hosp[illegible] bleeding has been observed immediately prior to a planned angi[illegible] quite natural therefore that this must sometimes happen after [illegible] and consequently should not necessarily be ascribed to the ex[illegible] none of the relevant cases did the fresh bleeding start during th[illegible] (Table 3) In subjects who are desperately ill, and suffering [illegible] progressing brain lesions or other fatal conditions the possibil[illegible] excluded that the angiographic examination may contribute to [illegible] particularly where general anaesthesia is used However, th[illegible] regarded strictly as complications, seven such cases were th[illegible] sidered to be caused by angiography One group of cases that [illegible] taneously to deteriorate is the one of circulatory insufficien[illegible] teriosclerosis or hypertension, or both Deterioration direct[illegible] examination in such cases must be regarded as a complication [illegible] hand nothing happens during the examination and immed[illegible] the relationship must be considered as doubtful With th[illegible] of the three cases of complications in this group can be ascri[illegible] These two cases which are briefly described below repre[illegible] complications in the material and the authors belie[illegible] where the risk lies

Table 3

Number of major accidents occurring in the postangiographic period

Number of	Accidents occurring	Ascribed to angiography
Renewed bleeding in intracranial aneurysms and arteriovenous anomalies	4	—
Death caused by other conditions	7	—
Deterioration in cases of arteriosclerotic and/or hypertensive disease	3	2
Occlusion of narrowed carotid artery no clinical signs	1	1

Male aged 60 with sign of reduced cerebral circulation Some deterioration in his condition occurred during an air study two days prior to the angiography Immediately following a right side carotid angiography signs of the presence of a cerebral lesion on the right side occurred No local lesion of the carotid artery could be detected in the angiograms or at the post mortem examination and the complication was therefore considered to be due to a temporary increase of anoxaemia due to the contrast medium circulating instead of blood

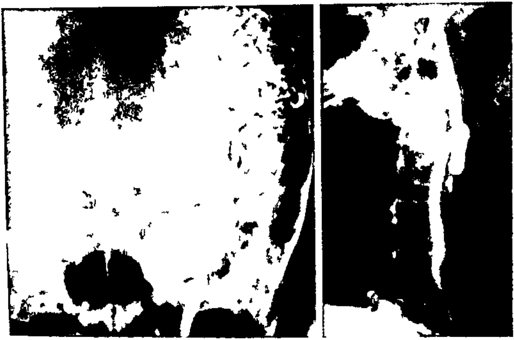
Male aged 75 years with signs of reduced cerebral circulation The catheter passed easily into the left internal carotid artery and the first injection demonstrated an occlusion of the anterior cerebral artery (Fig 3 a and b) The catheter was then withdrawn and the tip placed in the common carotid artery The second injection revealed nearly complete occlusion of the internal carotid artery just above the bifurcation (Fig 4 c) and it was observed that the contrast medium disappeared very slowly from the artery (Fig 4 d) The result of these two occlusions was to bring about infarction of the left hemisphere It is possible that immediate surgical intervention might have prevented the fatal outcome

The last mentioned case illustrates that the catheter can pass through a narrowed and almost occluded artery, and so produce total occlusion This may not generally lead to alarming signs because of the established circulation from the other side With the anterior cerebral artery occluded, however the circulation will be insufficient

Table 4

Number of minor complications occurring in the different groups examined

Complication		
Cervical haematoma (853 carotid angiographies)	Large	7
	Medium	11
	Small	96
Fore arm haematoma (118 vertebral angiographies)	Large	1
	Medium	1
	Small	1
Deterioration in vertebral basilar insufficiency (carotid angiography)		1
Minor temporary signs following vertebral angiography		7
Horner syndrome		5



a b



c d

Fig 3 Reduced cerebral circulation in a male aged 75 a) and b) Occlusion of anterior cerebral artery c) Catheter withdrawn and tip placed near the bifurcation nearly complete occlusion of internal carotid artery d) The medium disappears very slowly from the artery peripheral to the narrowing

Another case of incomplete carotid stenosis which became complete was diagnosed from the angiograms but the collateral circulation was satisfactory and no clinical signs followed the examination

As fluctuations in the level of consciousness are a part of the natural course in *cases of glioblastoma, four cases in which these occurred were excluded* from the material

The remainder of the complications noted were minor ones (Table 4) None of the haematomas, even those grouped as large, called for special measures Horner's syndrome occurred in 4 cases but persisted only in one case, it could probably be attributed to the local anaesthesia No serious sequelae followed the vertebral angiographies Minor temporary visual disturbances were occasionally noted

Comments and Conclusions

The risk of complications in cerebral angiography from the contrast medium, when used in moderate concentrations and doses, is relatively low Sequelae must therefore be avoided and their number reduced by careful attention to the technique, but as a hazard still remains in cases of incomplete occlusion of the carotid artery, cerebral angiography should in such cases preferably be performed by catheterization via the brachial or femoral artery

SUMMARY

An analysis of 971 angiographic examinations performed by catheterization of the common carotid artery or the vertebral artery in 803 cases is presented The importance of the angiographic technique in avoiding complications is stressed

ZUSAMMENFASSUNG

Es wird uber 971 angiographische Untersuchungen von 803 Fallen mittels Katheterisierung der Arteria carotis communis oder der Arteria vertebralis berichtet Die Wichtigkeit der korrekten Technik wird betont wenn man Unfälle verhuten will

RÉSUMÉ

L analyse de 971 examens angiographiques faits par cathétérisme de l artère carotide primitive ou l artère vertébrale chez 803 malades est présentée Les auteurs soulignent l importance de la technique angiographique pour la prévention des complications

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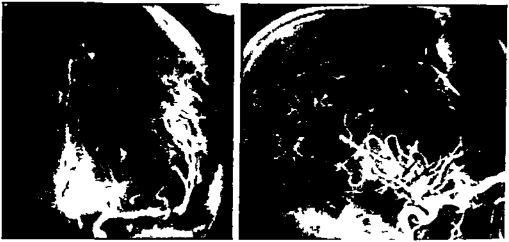
ANGIOGRAPHIC LOCALIZATION OF SMALL INTRACEREBRAL HEMATOMAS

by

POUL E ANDERSEN

The angiographic diagnosis of intracerebral hematomas was until recent years made from the changes in position of the large superficial vessels on the surfaces of the cerebral hemispheres A certain number of cases often as many as 20 or 25 per cent in many materials of cerebral apoplexy, were however said to have normal angiograms thus creating some difference in the value of angiography in the diagnosis of intracerebral hemorrhage Some of these cases had doubtless had either temporary circulatory insufficiencies or small thromboses of the finer branches of superficial or deep arteries although the discrepancy between the severity of the clinical signs and the inconspicuous arterial changes was great enough to constitute a challenge to the diagnostic abilities of the radiologist It would appear from the more recent materials (e g GORMSEN et coll) that 10 to 15 per cent of the cases of manifest massive apoplexy caused by intracerebral hematomas have silent angiograms A detailed study has therefore been made during the last 5 years of all those cases in which no or only slight displacements of the superficial vessels were found The present report is based upon 96 cases that all have been verified by operation or autopsy

The investigations of e g SJOGREN, DECKER LOFGREN, GREITZ drew attention to the deep, finer vessels such as the anterior and posterior choroid arter



a b

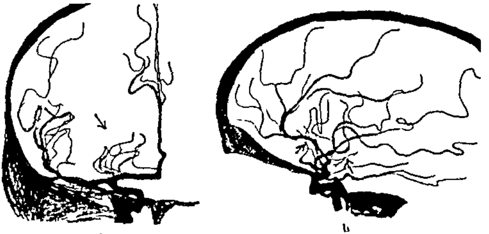
Fig 1 Case 1 a) A.p view Displacement (arrows) of lenticulostriate arteries b) Lateral view of same case

ies and the central veins, although the central arteries in the substance of the cerebrum were seldom mentioned

The ganglionic arteries, the lenticulostriate the lenticular lateral and the lenticulo-optic arteries, the angiography of which was described by the author in 1957, originate from the first part of the middle cerebral artery, occasionally from the anterior cerebral artery or the point of division of the siphon The artery lying most anteriorly in the basal ganglia, the Heubner artery may be very difficult to differentiate in the normal angiographic projections, whereas the lenticulostriate arteries are easily seen The course of the lenticulostriate arteries is upwards, backwards and slightly medial to the anterior perforate substance from whence in the form of a knee they course in a laterally convex curve upwards towards the bottom of the lateral ventricle through the basal ganglia and the internal and external capsule The posterior part of the basal ganglia is supplied from branches originating from the posterior communicating arteries and by the posterior choroid arteries

As the diameter in the angiograms of the lenticulostriate arteries seldom exceeds 0 1 to 0 2 mm it is important to obtain first class angiograms in the correct phase which is the first part of the arterial phase Rapid serial angiography of the Swedish type is if not indispensable, of great advantage With the present technique the branches from the posterior communicating arteries on account of their very small caliber, are seldom seen The posterior choroid arteries may be most valuable in the localization of occipital and temporo-occipital hematomas and should be demonstrated by vertebral angiography when not in evidence in the usual carotid angiograms

The contrast filling of the visible demonstrable part of the ganglionic arteries takes place early in the arterial phase and is only of short duration, usu



a b

Fig 2 Case 2 a) A p view Compression of lenticulostriate arteries No displacement of the pericallosal artery b) Lateral view of same case The lenticulostriate arteries are slightly pushed apart

ally 0 5 to 1 5 sec with the present injection technique, naturally depending on the duration of the injection As the length of the vessels is shorter than that of most superficial vessels the medium will have disappeared when the filling is optimal in the posterior parts of the branches of the middle cerebral arteries if only a small amount of medium is used as in common practice The filling of the efferent veins, the thalamostriate vein and the vein of the posterior horn is usually of longer duration and especially in the a p view the position of the thalamostriate vein may be of considerable value in the diagnosis of a thalamic or subcortical parietal hematoma

The course of the lenticulostriate arteries is very constant and regular and it is obvious that even small space occupying lesions will probably affect these arteries in a diagnostically useful way, this is in contrast to the well known discrepancy between a surprisingly large tumour and the rather insignificant displacements of superficial vessels that are occasionally encountered

A few cases will be described to illustrate the changes in the central cerebral arteries especially the lenticulostriate arteries in cerebral hematomas Similar changes that amplify and substantiate the reports on these cases have been noticed in combination with typical apoplexy in numerous cases without surgical or autopsy verification

Case 1 Deep frontal hematoma Woman aged 50 with a history of epileptic seizures between 5 and 7 years of age On the day of admission she had fainted for a few minutes and some hours later developed a moderate right hemiparesis

Angiography (Fig 1) Slight displacement of the pericallosal artery towards the right side, the lenticulostriate arteries were divided and displaced medially and backwards the venous angle as seen in the lateral view was elevated and displaced backwards A diagnosis of a frontal hematoma extending backwards into the internal capsule was made



Fig 3 Case 3 Displacement of the lenticulostriate arteries

Operation A large hematoma located about 2 5 cm below the surface was evacuated from this region no aneurysm could be demonstrated The postoperative course was without complications and the patient is well 4 year after the operation

Case 2 A fronto parietal hematoma with perforation to the lateral ventricl Woman aged 47 with sudden left hemiparesis no previous symptoms

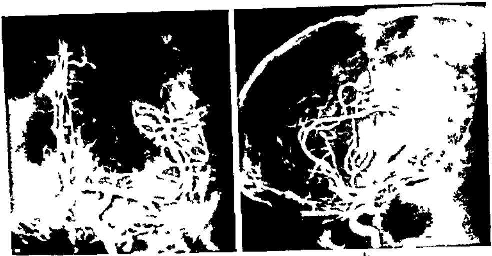
Angiography (Fig 2) Space occupying lesion producing (a p view) compression and displacement of the lenticulostriate arteries and (lateral view) some division of these arteries As no displacement of the pericallosal artery was evident a hematoma perforating to the surface or to the lateral ventricle was diagnosed

Operation A hematoma (about 50 ml blood) was found in the location indicated with a perforation to the lateral ventricle The hematoma was evacuated but the patient died a few days later At autopsy a plum sized cavity was found with a connection to the middle part of the lateral ventricle All the ventricles were filled with blood no angioma aneurysm or tumour was found

Case 3 Hematoma in the postero-medial part of the temporal lobe Woman aged 25 was admitted after brief unconsciousness with convulsions and in a poor condition

Angiography (Fig 3) showed displacement of the lenticulostriate arteries locally delayed circulation in the middle cerebral artery and displacement of the posterior part of the anterior choroid artery The diagnosis of a space-occupying lesion presumably a hematoma with perforation into the postero-medial part of the temporal lobe was made Craniotomy showed cherry red fluid respiration ceased abruptly and in spite of all efforts the pati nt died At autopsy a hematoma the size of a walnut was found in the posterior part of the basal ganglia and the medial part of the temporal lobe with perforation to the lateral ventricle and the surface of the hemisphere in the middle cranial fossa

Case 4 Hematomas in the corpus striatum and external capsule Man aged 54 with a history of gastric ulcer who 7 hours prior to admission suddenly developed right hemiparesis



a b

Fig 4 Case 4 a) A p view The lenticulostriate arteries are compressed and angulated b) Delayed circulation in middle cerebral artery displacement of lenticulostriate arteries and anterior choroid artery

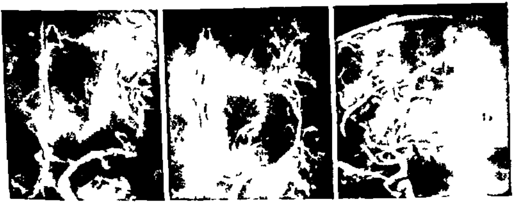
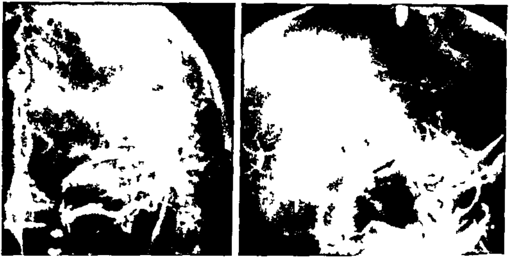


Fig 5 Case 5 Displacement of lenticulostriate arteries slight elevation of middle cerebral and anterior choroid arteries The pericallosal artery is not shifted

Angiography (Fig 4) Displacement of the central arteries probably by a hematoma in the lateral part of the basal ganglia this was verified at autopsy which disclosed two hematomas in the lateral part of the corpus striatum and the external capsule one in the anterior part and the other one below the posterior part of the lateral fissure extending towards the surface

Case 5 A large hematoma in the occipital lobe and extending downwards below the trigone of the ventricle into the external capsule and the posterior part of the temporal lobe Man aged 45 with diabetes of 25 years duration and ineffectively controlled had severe hypertension and suddenly became paretic and aphasic

Angiography (Fig 5) No definite displacement of the pericallosal artery but some elevation of the middle cerebral artery The lenticulostriate arteries however were somewhat raised



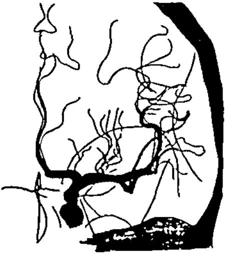


Fig 6 Case 6 Nut sized malacia in claustrum and external capsule left side Lenticulostriate arteries almost laterally concave above the knee In the lateral view they are pressed forwards and the anterior choroid artery is also slightly displaced

and displaced medially with the anterior choroid artery displaced slightly in the same direction Some draping of the posterior ramifications of the middle cerebral artery was perhaps also present The above mentioned diagnosis was made in view of the absence of displacement of the pericallosal artery.

Autopsy Large hematoma below the floor of the lateral ventricle extending backward into the occipital lobe and lying mainly in the external capsule and extending down into the temporal lobe

Case 6 A small hematoma in the external capsule and claustrum Woman aged 75 who 3 days prior to admission had paraesthesia of the right side of the face and the right extremities of short duration On the day of admission she developed moderate loss of strength of the right hand which however soon disappeared

Angiography The lenticulostriate arteries were impressed from the lateral side with formation of a knee instead of the normal lateral convex curve The anterior choroid artery appeared in the lateral view to be displaced downwards and forwards in its plexal part suggesting a small space-occupying lesion in the external capsule region perhaps extending



Fig 7 Case 7 Elevation of the knee of the lenticulostriate arteries in the frontal view Depression of the posterior cerebral and posterior choroid arteries in the lateral view

into the temporal lobe As the cerebrospinal fluid was quite clear and no definite displacement of the pericallosal artery was present the condition was either one of a very small non penetrating hematoma or more questionably a small tumour

The patient suddenly died of respiratory failure a few days later Sections through the brain disclosed malacia of nut size in the external capsule and the claustrum as well as numerous petechial bleedings in the thalamus the cause of which was unknown

Case 7 Woman aged 39 with an unusual history She had a minor but typical stroke with right hemiparesis when she was 16 from this she had recovered completely and was well up to 7 days before admission when she developed slight symptoms referable to the right extremities She was considered to have a subarachnoid hemorrhage she grew unconscious but reacted to painful stimuli The EEG was taken many times and was grossly abnormal but without any indication as to the condition The course of her illness was eventful and many complications occurred she died 6 1/2 months after the first subarachnoid bleeding

Bilateral carotid angiography was performed shortly after admission and this was repeated a week later following ventriculography The angiograms were identical and disclosed a central space-occupying lesion presumably in the inferior medial parts of the basal ganglia extending down into the mesencephalon and the pons The lenticulostriate arteries were stretched in the frontal as well as in the lateral view with almost total obliteration of the knees of their courses The posterior cerebral and the posterior choroid arteries were pressed downwards in a curve with the posterior medial choroid artery considerably displaced dorsally The ventriculograms revealed slight backward tilting of the upper part of the fourth ventricle and some angulation of the aqueduct confirming the localization of the hemorrhage to the region ventral to the latter Vertebral angiography was attempted but was unsuccessful

Autopsy Malacia was evident in the upper part of the pons and just below the floor of the fourth ventricle and the aqueduct there was also a more recent hemorrhage that extended upwards through the mesencephalon to the subthalamic regions especially on the left side and into the postero-inferior parts of the internal capsule

Ventriculography had shown a slight distension of the left temporal horn and this was confirmed the other ventricles were normal The superficial vessels were quite normal without atheromatosis or aneurysms and no pathologic changes could be found in the circle of Willis the basal or vertebral arteries The cause of the subarachnoid hemorrhages consequently remained unknown

Discussion

The writer has thus found that the lenticulostriate arteries, alone or in combination with the choroid arteries, are of considerable value in the diagnosis of small intracerebral hematomas, especially in the central parts of the hemispheres An evaluation of the size of the hematoma, the volume of the clot, is of course difficult and can usually only be a rough estimation It is sometimes surprising how considerably displaced the deep arteries may be without any definite displacement of the superficial vessels When the hematoma is still confined in the cerebral substance, there is almost always slight to considerable displacement of the superficial vessels However, if the intrahemispheric pressure and the increase of volume have been relieved by perforation at the brain surface or inwards to the ventricular system, the displacement of the pericallosal and/or middle cerebral arteries is insignificant and within normal variations The deep seated, finer arteries, however, in the neighbourhood of the bleeding are still influenced and impressed and thus allow an exact localization

When the hematoma is situated in the occipital lobe and adjoining parts of the temporal lobe and parietal lobe, or a flat hematoma lies in the posterior part of the external capsule, the superficial arteries are usually not displaced and the central vein may not be shifted A slight tilting of the thalamostriate vein in these cases in the frontal view, and of the posterior choroid and striate arteries in the lateral view, and/or frontal view may be the only clue to the localization The correct diagnosis of occipital hematomas in many cases still remains difficult

SUMMARY

The displacement of the vessels supplying the basal ganglia in cases of intracerebral hematoma is discussed It is shown that the superficial vessels are of lesser value especially in case of a perforating hematoma

ZUSAMMENFASSUNG

*Die Verdrangung der Blutgefässe die die Basalganglien versorgen bei Fällen von intracere*bralem Hamatom wird erortert Es wird festgestellt dass die oberflachlichen Gefässe von geringem diagnostischen Wert sind wo ein perforierendes Hamatom vorliegt

RÉSUMÉ

L auteur etudie le déplacement des vaisseaux des noyaux gris centraux dans des cas d hématome intracérébral Il conclut que les vaisseaux superficiels présentent moins d intérêt en particulier en cas d hématome perforant

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PHLEBOGRAMME CEREBRAL PROFOND DE FACE ET SES VARIATIONS EN CAS DE PROCESSUS EXPANSIFS DE L'ESPACE INTRA-CRANIEN SUS-TENTORIEL

par

J. BAUMGARTNER, E. WORINGER, J.-P. BRAUN et M. ABADA

L'étude du phlébogramme cérébral profond a déjà maintes fois été entreprise; nous ne citerons à ce sujet, parmi les auteurs qui en ont fait une étude plus approfondie que les noms de E. MONIS, ALM. LIMA, RICHTER, JOHANSON, MASPES et DONEGANI, RIEMENSCHNEIDER et ECKER, LAINE, DELANDSHEER et GALIBERT, WOLF, NEWMAN et SCHLESINGER, BONNAL et LEGRE. La valeur du phlébogramme de face a été soulignée d'une façon unanime mais ce n'est que dans un travail de RIEMENSCHNEIDER et ECKER (1954) que nous avons trouvé des identités de vue se rapprochant des nôtres. Ces auteurs ont signalé la possibilité de reconnaître et de situer un processus expansif de l'espace intra-crânien dans la portion antérieure ou postérieure de l'hémisphère cérébral selon la déviation sur les clichés de face de la portion antérieure ou postérieure de ce phlébogramme. C'est cette déviation latérale par rapport à la ligne médiane du phlébogramme profond de face que nous nous proposons d'étudier à la lumière de quelques-uns de nos clichés.

Une première partie sera consacrée au phlébogramme profond normal tel qu'il se présente sur les radiographies de face. Il mérite certains commentaires. Ensuite, nous voudrions, à l'appui de divers exemples, montrer les déformations assez caractéristiques de ce phlébogramme en rapport avec la topographie même des processus expansifs de l'espace intra-crânien sus-tentoriel.

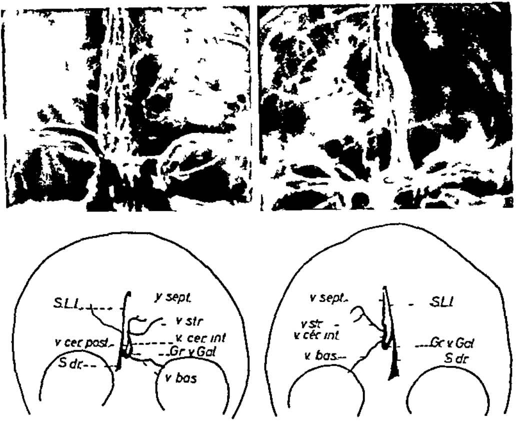


Fig 1 Phlébogramme profond normal de face démontrant grande veine de Galien veine basilaire veine cérebrale interne veine cérébrale posterieure veine du septum lucidum, sinus droit sinus longitudinal inferieur Sur l image de gauche il existe une opacification discrete du phlébogramme profond heterolateral

1 Phlebogramme cerebral profond normal de face

Cette etude comportera la description des images des differentes veines et sinus telles que leur opacification nous les fait apparaitre avec le plus de regularite au cours de l angiographie cerebrale Nous n en donnerons aucune relation anatomique celle ci a deja ete maintes fois entreprise et la monographie de JOHANSON (1954) en constitue une excellente mise au point

Les elements du phlebogramme profond visibles habituellement sur la projection de face dans les cas normaux et pathologiques sont constitues par deux sinus et une serie de veines Les premiers sinus longitudinal inferieur et droit les autres veines du septum lucidum opto-striee cerebrale interne cerebrale posterieure basilaire et ampoule de Galien Ces differents elements veineux constituant le phlébogramme profond de face peuvent etre classes en deux systemes essentiels un systeme veineux median et un systeme veineux lateral (Fig 1)

Le systeme median du phlebogramme profond de face est constitue par les deux sinus, le sinus longitudinal inferieur en avant et le sinus droit en arriere et par un ensemble de veines qui sont d avant en arriere la veine du septum lucidum, la veine cerebrale interne ou petite veine de Galien, la veine cerebrale posterieure et enfin l ampoule de Galien ou grande veine de Galien

Le systeme lateral du phlebogramme profond de face comporte deux veines la veine strio-thalamique et la veine basilaire de Rosenthal qui viennent se joindre toutes deux sur la ligne mediane au systeme median, l une a son extremite anterieure l autre a son extremite posterieure

C est l etude des differents elements veineux constituant les formations mediane et laterale du phlebogramme profond de face qui sera maintenant entreprise

A — *Systeme veineux median*

L ensemble des elements de ce systeme se projette verticalement sur la ligne mediane en se superposant partiellement Contrairement a ce qui est parfois admis les differents constituants de ce systeme median peuvent parfaitement etre determines et delimites sur une plus ou moins grande partie de leur parcours

1 *La petite veine de Galien ou veine cerebrale interne* Elle occupe habituellement avec la grande veine de Galien la majeure partie de l opacite verticale que represente le systeme median Son deroulement comme celui de tous ces elements veineux depend de la projection des rayons roentgens Sur nos cliches de face elle s etale habituellement sur une hauteur de 10 a 15 mm qui dans des cas extremes peut atteindre 2 a 3 mm ou au contraire 2 cm et davantage Cette hauteur, comme celle d ailleurs de tous les elements veineux du systeme median depend de la projection meme des rayons etalee pour la projection antero-posterieure elle diminue et elle peut meme devenir ponctiforme pour la projection demi axiale ou axiale

Son extremite anterieure se situe presque toujours sur la ligne mediane ou en est distante d 1/2 a 1 mm Cette extremite anterieure peut particulierement bien etre reconnue a cause de la veine opto-striee qui rejoint a son niveau le systeme median en un point qui correspond sur le cliche de profil au sommet de l angle veineux Son extremite posterieure par contre se continue sans transition avec la grande veine de Galien et avant d y penetrer est distante de la ligne mediane d environ 1 mm de plus que l extremite anterieure Cette extremite posterieure n est jamais localisee avec precision sur le phlebogramme de face Le point de jonction entre la veine basilaire et l ampoule de Galien en permet une appreciation relative

2 *La grande veine de Galien ou ampoule de Galien* Cette veine resultant de la reunion des deux petites veines de Galien prend frequemment sur nos projections radiographiques de face la forme d un grand L ou d un grand V ouvert vers le haut elle presente dans ces cas un premier segment descendant faisant

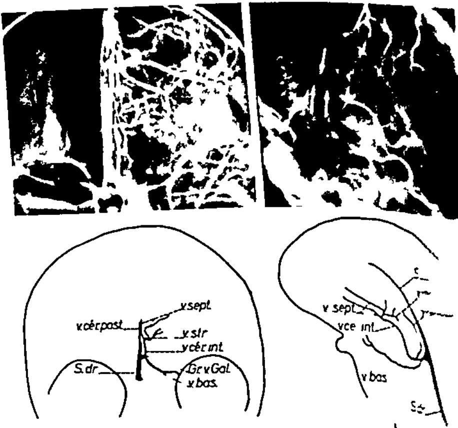


Fig 2 Phlebogramme cerebral profond normal de face et de profil Prése... lucidum

immediatement suite par son extremite superieure a la petite ...
le 2e segment prend une direction ascendante et va rejoind...
terieure du sinus droit a l endroit meme ou s y jette égalem...
tudinal inferieur Les deux segments de l ampoule de Galien ...
ongueur inegale c est le premier segment qui reçoit habitu...
basale Cette jonction permet toujours de determiner l a...
sans cependant en preciser la limite anterieure qui corresp...
tion de la petite veine de Galien

3 *La veine du septum lucidum* Lorsqu elle est visible cette ...
la ligne mediane ou au maximum a 1 mm d elle Elle s'é...
sur une longueur variant entre quelques millimetres et ...
l angle veineux cerebral et se dirige au dessus ou en d...
selon l incidence du rayon central par rapport au plan ...
situation haute ou basse de cette veine sur le septum lucidum ...
cale correspond a son cheminement sur le septum lucidum ...

initiale, situee sur la paroi anterieure de la corne frontale, est opacifiee dans ce cas elle apparait comme une opacite filiforme plus ou moins horizontale, longue de 1 a 2 cm, se dirigeant de l'exterieur vers la ligne mediane ou elle rejoint a angle droit la portion verticale susdecrite Parfois il existe plusieurs veines du septum lucidum (Fig 2)

4 *Le sinus longitudinal inferieur* Lorsqu il est opacifie le sinus longitudinal inferieur prend frequemment la forme de deux lignes verticales generalement tres fines situees sur la ligne médiane, au dessus de la veine cerebrale interne et de la grande veine de Galien Elles se rejoignent a leur extremite superieure en formant un angle aigu Ces deux lignes ont une longueur globale de 2 à 3 cm environ et sont de taille inegale L'extremite anterieure du sinus longitudinal inferieur correspond a la branche la plus courte et peut se confondre avec la branche verticale de la veine du septum lucidum sur une partie au moins de son trajet La ligne la plus longue correspond au segment posterieur et se jette dans le sinus droit a l endroit meme ou s y jette egalement la grande veine de Galien Parfois ce dernier segment est seul visible

5 *Le sinus droit* Habituellement plus large, il est aussi souvent plus contraste que les elements veineux precedents Ce sinus peut avoir une longueur equivalente a celle du sinus longitudinal inferieur dont il continue la direction Il est forme par la confluence du sinus longitudinal inferieur et l ampoule de Galien qui delimite son extremite anterieure Son extremite posterieure (correspondant a sa portion inferieure phlebographique) est elargie en un lac, le pressoir d Herophile par lequel il communique avec le sinus lateral Cette extremite posterieure ne se situe pas toujours strictement sur la ligne médiane

6 *La veine cerebrale posterieure* Appliquée sur la face superieure du corps calleux elle contourne le splenium pour se jetter dans la veine cerebrale interne ou dans l ampoule de Galien Cette veine est rarement visible sur un phlebogramme normal de face Elle prend cependant une importance considerable dans certains cas pathologiques une translation laterale des differents eléments du systeme median peut parfaitement bien permettre son individualisation Son abouchement dans la veine cerebrale interne ou dans la grande veine de Galien, permet suivant les cas de bien situer ces derniers vaisseaux

Rappelons pour resumer le systeme median du phlebogramme profond de face, que dans son ensemble il prend un aspect vertical et median Ses differents élements peuvent plus ou moins bien etre individualises et reconnus suivant qu il s agit d une projection antero postérieure, demi axiale ou axiale De plus les veines du systeme lateral que nous proposons d étudier maintenant, nous fourniront des points de repere importants pour le demembrement de ce systeme median

B — *Systeme latéral du phlebogramme profond de face*

1 *La veine thalamo striée ou veine opto striee* D une longueur phlébographique de 3 à 4 cm elle prend une direction oblique de haut en bas et de l extérieur

vers la ligne médiane Elle atteint ainsi la veine cerebrale interne avec laquelle elle forme l angle veineux cérébral qui constitue un repere important puis qu il est visible sur les cliches de face et de profil et qu il correspond habituelle ment au bord posterieur du trou de Monro

2 *La veine basilaire de Rosenthal* Longue de 3 a 4 cm elle prend une direction oblique en cheminant de bas en haut et de l exterieur vers la ligne mediane ou elle se joint à la grande veine de Galien en un point variable mais se projetant generalement sur nos cliches à une distance comprise entre quelques millimetres et 1 a 2 cm au dessous de l angle veineux Là encore, suivant la direction du rayon central par rapport a la masse cranio encéphalique, ce point de jonction peut varier et meme se situer au dessus de l angle veineux apres avoir entrainé un croisement des veines opto-striee et basale de Rosenthal Suivant qu elle est reperee sur une projection antero-posterieure ou demi axiale, cette veine presente également une anse ou simplement une sinuosite sur son parcours Cette modification ne nous intéresse dans cette étude que dans la mesure ou elle nous permet de mieux reconnaitre cette veine

Selon le deroulement des differents eléments phlébographiques on peut donc reconnaitre, grace aux points de jonction des elements du systeme lateral avec ceux du systeme median, un repere anterieur et un repere posterieur Le repere anterieur correspond a l extremite anterieure de la veine cerebrale interne et donc a l angle veineux et au trou de Monro le repere posterieur correspond a un point situe a un niveau variable de l ampoule de Galien Ce niveau peut parfaitement etre determine sur le cliche de profil, puis transpose sur le cliche de face

Contrairement a ce qui est generalement admis dans les cas pathologiques, il peut y avoir dissociation nette entre le deplacement lateral de cette portion anterieure et posterieure du phlebogramme profond, elle meme en rapport direct avec la situation antérieure ou posterieure du processus occupant l espace intra cranien

Interpretation du phlebogramme profond de face

Nous desirons dans ce paragraphe insister sur plusieurs points particuliers qui nous paraissent utiles a connaitre pour l interpretation correcte du phlebogramme profond de face

Le demembrement du phlebogramme profond de face en ses divers eléments se fait parfois difficilement En cas de bonne opacification des deux systemes veineux (median et lateral) il sera cependant toujours possible de delimiter les portions anterieure et posterieure du phlebogramme Nous savons en effet que la veine strio-thalamique rejoint le systeme vieneux median dans sa portion anterieure et que la veine basilaire de Rosenthal s y jette dans sa portion posterieure Ces deux points de jonction deviennent donc importants du fait qu ils permettent dans les cas normaux et pathologiques de reconnaitre sur les clichés de face la portion anterieure ou postérieure du systeme veineux median

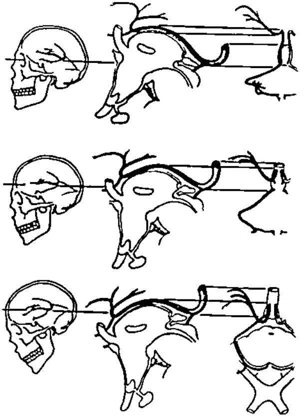


Fig 3 (D apres WOLFF NEWMAN et SCHLESINGER)
La colonne de gauche indique la direction des rayons rontgen par rapport au crane la colonne médiane donne la même indication par rapport aux éléments veineux vus de profil et enfin la colonne de droite nous montre les déformations de ces éléments veineux vus sur l image de face Sur cette dernière colonne on aperçoit nettement en haut le déroulement des différents éléments veineux qui sont par contre entièrement superposés en bas On reconnait également les points de jonction de la veine basilaire et de la veine strio thalamique avec les éléments de la ligne mediane qui sont eloignés l une de l autre en haut pour se rapprocher au milieu et même s entrecroiser en bas Ces modifications sont en rapport direct avec la direction des rayons rontgen par rapport à la masse cranioencephalique

et, en cas de deviation du phlebogramme, d apprecier la translation laterale relative de l une ou l autre de ces deux portions Il n est pas inutile de rappeler que l interprétation correcte du phlebogramme profond de face exige egalement sa lecture sur les cliches de profil En effet les deux points de jonction des veines strio thalamique et basilaire de Rosenthal avec le systeme veineux median sont sujets a des variations restant dans le cadre des limites normales mais dont l existence doit etre bien établie sur le cliché de profil afin de pouvoir eventuellement les transposer sur les clichés de face

Le cliche correspondant au phlébogramme est parfois tire a un stade plus ou moins avance ou tardif de la revolution circulatoire cerebrale Toutes les veines du phlebogramme profond (qui seules nous interessent ici) ne sont pas toujours opacifiees simultanement du fait des variations parfaitement normales, au moment de la penétration du contraste dans le reseau vasculaire cerebral Toutes les veines n etant pas opacifiées sur un meme cliche, celui ci peut etre d interprétation douteuse Cette eventualité ne survient plus si l on dispose d un seriangiographe permettant par la multitude des cliches phlébographiques de reconstituer l ensemble du phlebogramme profond

Le phlebogramme profond se projette fréquemment sur d autres éléments veineux (en particulier le sinus longitudinal supérieur) mais aussi sur les opa

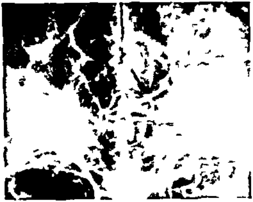


Fig 4 Asymétrie de la veine strio-thalamique gauche par rapport à la droite sur un phlébogramme normal

cites du massif osseux facial ce qui rend fréquemment sa lecture difficile sinon impossible Cette dernière éventualité peut être supprimée si au lieu de pratiquer une projection antéro-postérieure on pratique une projection semi axiale La projection semi axiale a malheureusement le gros inconvénient de reproduire une image des éléments veineux pris en enfilade et par conséquent plus ou moins ramassés sur eux mêmes En projection antéro-postérieure par contre ces éléments veineux sont bien déroulés permettant ainsi la bonne mise en évidence des parties antérieure et postérieure du phlébogramme et par conséquent également des éventuelles modifications sélectives de ces deux segments

Nous n avons tenu compte dans les déformations du phlébogramme profond de face que de sa déviation latérale par rapport à la ligne médiane Le déplacement dans le sens de la hauteur des différents éléments phlébographiques (en particulier de la formation latérale) n a nullement été envisagée et cela pour deux raisons essentielles

1 Sur un phlébogramme normal de face la disposition des différents éléments veineux qui le constituent peut en effet varier dans le sens de la hauteur chez un même sujet suivant l angulation que l on imprime au rayon central par rapport à la masse cranio-encéphalique ou suivant la position plus ou moins fléchie de la tête par rapport au plan horizontal Or il est pratiquement impossible de maintenir constante d un examen à l autre chez un même sujet et plus encore d un individu à l autre ce rapport entre rayonnement central des rayons roentgen et masse cranio-encéphalique

Wolf et Newman ont démontré dans un remarquable travail les variations en hauteur des éléments phlébographiques du système latéral chez un même sujet chez qui on modifie uniquement l angle de flexion de la tête (ce qui correspond à une modification du rayon central) Leur schéma est suffisamment démonstratif (Fig 3)

2 Une 2e raison nous a incités à ne pas tenir compte des modifications dans le sens vertical des différents éléments du système latéral chez le sujet normal

la même veine de ce système, veine strio thalamique ou veine basale peut avoir une allure différente d'un coté par rapport a l'autre sur le cliché de face L'image phlébographique que nous reproduisons ci joint represente une opacification bilaterale du phlébogramme profond au cours d une angio graphie carotidienne unilaterale (Fig 4) Il s agit la 'd une asymétrie normale concernant la veine strio thalamique Nous pensons donc que seule la dévia tion laterale du systeme median par rapport a la ligne médiane permet de nous donner une indication topographique precise

II Phlebogramme cerebral profond de face dans les processus expan sifs de l'espace intra-cranien sus-tentoriel

A l'occasion de ce travail nous avons revu une serie de 91 observations con cernant toutes des processus occupant l espace intra cranien sus tentoriel Il s agit dans la presque totalité des cas de tumeurs ou d'hematomes intraparen chymateux d apparition spontanée, et donc non traumatique, dont la localisa tion a pour chacun d'entre eux eté vérifiée opératoirement Avant d entre prendre leur étude proprement dite nous voudrions encore rappeler quelques notions d'ordre géneral concernant les anomalies phlebographiques rencontrées sur nos cliches de face

Lorsque dans ce travail nous parlons de modifications topographiques du phlébogramme profond de face, nous voulons toujours dire deplacement latéral par rapport a la ligne mediane Nous n avons donc tenu compte que d une déviation laterale au dela de la ligne médiane, soit de la formation médiane soit des points d abouchement de la formation laterale du phlébogramme Un de placement en hauteur de la formation latérale (veine basilaire et strio thalami que), qui peut etre abaissee ou surélevee, n a pas eté envisagé dans cette etude pour des raisons decrites dans le chapitre precedent

Nous avons essaye de demontrer que le phlébogramme profond de face pouvait etre deplacé dans ses portions antérieure ou posterieure, l une pre ferentiellement a l autre selon la localisation anterieure ou postérieure de la lesion cerebrale La majorité des auteur qui en ont fait l étude n ont habituelle ment pas fait cette distinction

Il est par ailleurs généralement admis surtout depuis les travaux de JOHAN SON d une part de LAINE DELANDSHEER et GALIBERT d autre part, que des lésions hemisphériques antérieures entrainent une déviation importante de l artere cerebrale anterieure, non accompagnée d une deviation correspon dante ou en tout cas nettement moins importante du phlebogramme profond Inversement une lésion expansive hémisphérique postérieure, surtout lors qu elle est profonde n entrainerait qu un minime deplacement de l artere céré brale anterieure alors que le phlébogramme profond serait dans ces cas tou jours refoule vers l hemisphere opposé

Dans cette façon de voir il n a donc pas été tenu compte des portions anté rieure ou posterieure du phlebogramme qui peuvent d une façon selective etre

plus ou moins deviees l une par rapport a l autre D ailleurs cette dissociation arterio-veineuse est loin d etre constante et l on peut observer, comme nous le verrons une lesion expansive anterieure avant entraine une deviation plus importante du phlebogramme profond que de l artere cerebrale anterieure et inversement Il est neanmoins possible qu un processus d un volume defini entraine une deviation legerement plus importante au niveau du phlébogramme profond anterieur (s il siege dans la region anterieure) qu il ne le ferait au niveau du phlebogramme postérieur (s il siegeait dans la region posterieure) Le point d abouchement du phlébogramme profond postérieur dans le sinus droit constitue en effet une amarre fixe, au moins en ce qui concerne les dé placements lateraux et ne permet donc aux formations situees immédiatement en avant de lui, que des mouvements de lateralité dont la latitude reste relative ment reduite

Il est important de souligner ici qu en cas de deplacement du systeme veineux profond les elements veineux faisant partie de ce deplacement peuvent etre etires et donc allonges comme tout autre element vasculaire soumis à une poussee expansive Ceci est particulierement vrai en ce qui concerne la grande veine de Galien qui lorsqu elle est deviee peut subir un alongement et donc un deplacement superieur a ce que lui permettrait sa taille normale Sa fixite de par son amarrage au sinus droit n est donc que relative et n existe en réalité qu a son point d abouchement

Un dernier point d ordre général nous semble utile de souligner avant d entreprendre l etude des differents cas particuliers Au cours de l angiographie cerebrale les divers processus occupant l espace intra cranien impriment aux differents vaisseaux opacifies des deformations qui peuvent etre caractéristiques pour une localisation donnee Il n en est malheureusement pas toujours ainsi car le processus occupant peut ne pas etre le seul facteur de compression il peut s y ajouter la compression due a l œdeme perifocal ou à l hypertension intracranienne generalisee Tous ces facteurs agissant a distance peuvent modifier la deformation determinee par le processus primaire si bien qu il ne sera plus possible d attribuer regulierement une certaine deformation à une localisation bien precise Il en sera de meme pour certaines lesions intra craniennes diffuses et etendues qui par leur compression a distance ne provoquent plus les modifications caracteristiques d une lesion localisée Les hématomes extra cerebraux sous ou sus dure meriens n ont pour cette raison pas été inclus dans cette etude

Revue de nos observations

Pour chacune des observations nous avons recherche sur les clichés angiographiques de face le deplacement lateral au dela de la ligne médiane des differents elements du phlebogramme profond et nous l avons comparé, lors qu il existait a celui de l artere cerebrale anterieure a l endroit même ou il etait a son maximum

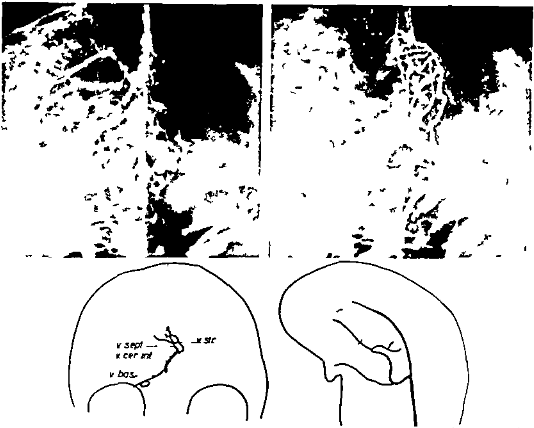


Fig 5 Tumeur frontale externe Déviation laterale au-delà de la ligne médiane de la portion antérieure du phlebogramme profond (deplacement maximum de 15 mm) alors que sa portion postérieure se situe strictement sur la ligne mediane — Le deplacement arteriel maximum est de 19 mm

Tableau 1

Lésions de la region frontale (35 cas)

Localisation	Deplacement artériel superieur au déplacement veineux	Deplacement artériel identique au déplacement veineux	Deplacement artériel inférieur au déplacement veineux
Pole frontal (2 cas)	Pas de déplacement ni artériel ni veineux		
Fronto-basale médian (1 cas)	1		
Fronto-basale latéral (6 cas)	3	3	
Frontale externe (11 cas)	5	1	5
Frontale parasagittale (6 cas)	1	4	1
Frontale postérieure (4 cas)		3	1
Frontale globale (5 cas)	2	1	2

D'emblée nous avons éliminé 8 observations où la mauvaise qualité du cliché n'a pas permis l'interprétation du phlébogramme. Certains autres clichés quoique mauvais du point de vue technique ont néanmoins pu être interprétés et donc utilisés pour cette statistique. Les 83 observations retenues ont été catégorisées suivant la localisation cérébrale de la lésion en régions frontale (35 cas), temporale (23 cas), pariétale (16 cas), et occipitale (6 cas). Chacune de ces localisations a elle-même été subdivisée en sous-groupes.

A — *Région frontale*

Sur nos 35 cas de lésions frontales groupées dans le Tableau 1 deux fois seulement il n'y a eu ni déplacement artériel ni déplacement veineux. Dans 12 cas le déplacement artériel était supérieur au déplacement veineux, dans 9 cas c'était l'inverse et dans 12 cas il était identique pour les deux.

Il est intéressant de noter que dans les cas où il existait un déplacement veineux celui-ci intéressait toujours la partie antérieure du phlébogramme profond: partie antérieure de la veine cérébrale interne, la portion terminale de la veine du septum lucidum et de la veine opto-striée et l'extrémité antérieure du sinus longitudinal inférieur. Jamais la partie postérieure du phlébogramme profond n'a suivi la translation latérale. Ces constatations sont illustrées par les observations que nous donnons ci-après.

1. *Tumeur frontale externe* (Fig. 5). Homme de 65 ans. Il s'agit d'une métastase unique d'un épithélioma cylindrique de forme kystique et uniformément ronde d'un diamètre d'environ 4 cm située en dehors de la corne frontale dont la face externe forme la paroi supérieure et interne du kyste. La poussée horizontale exercée par la tumeur provoque une déviation latérale sous la faux du cerveau du système ventriculaire en particulier de la région du trou Monro qui entraîne avec elle les formations veineuses voisines, c'est-à-dire l'angle veineux cérébral. Détail important: la partie terminale de la veine opto-striée présente la plus forte déviation, celle de la veine du septum lucidum est moindre et enfin la veine cérébrale interne revient sur la ligne médiane dans son trajet postérieur. Il n'y a aucune déviation du phlébogramme profond postérieur. Le sinus longitudinal inférieur n'apparaît pas.

Il faut relever que malgré une localisation frontale l'artère cérébrale antérieure ne présente qu'une déviation de 4 mm supérieure à celle du phlébogramme profond antérieur.

2. *Glioblastome frontal global et parasagittal* (Fig. 6). Femme de 66 ans. Il s'agit ici d'un glioblastome de localisation frontale globale et parasagittale qui a entraîné une déviation latérale de la portion antérieure du phlébogramme profond alors que sa portion postérieure se situe à nouveau sur la ligne médiane. Le déplacement maximum est celui de la veine du septum lucidum qui atteint 18 mm. L'angle veineux présente un déplacement moindre ainsi que la portion antérieure du sinus longitudinal inférieur qui atteint cependant 13 mm. L'artère cérébrale antérieure est déviée de 20 mm.

Il est intéressant de noter que la tumeur de localisation frontale globale et parasagittale entraîne non seulement un déplacement des formations voisines de l'angle veineux, mais aussi du sinus longitudinal inférieur. Celui-ci de par sa situation par rapport à la tumeur est soumis directement à la poussée latérale de cette dernière. Il est donc déplacé dans la mesure que le lui permettant ses différentes attaches et dans ce cas particulier son amarre à l'apophyse crista galli. Il est intéressant également de souligner que le déplacement artériel n'est supérieur à celui du phlébogramme profond que de 2 mm malgré la localisation frontale de la tumeur.

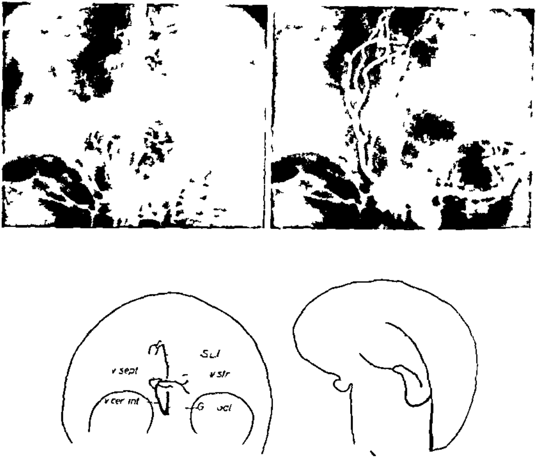


Fig 6 Glioblastome frontal global et parasagittal Deplacement de la portion anterieure du phlebogramme profond (18 mm) (veine septal veine opto-striée et partie antérieure de la veine cerebrale interne) et de la partie anterieure du sinus longitudinal inférieur (13 mm) Déplacement artériel maximum de 20 mm

Tableau 2

Lesions de la région temporale (23 cas)

Localisation	*Déplacement artériel* supérieur	identique	inférieur au déplacement veineux
Temporale antérieure (11 cas)	0	2	9
Temporale postérieure (3 cas)	1	2	0
Temporale globale (9 cas)	1	1	7

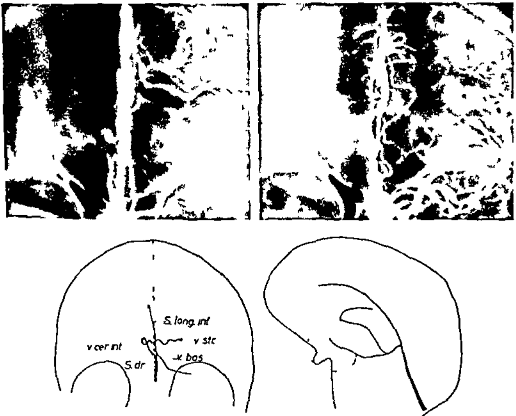


Fig 7 Hematome intra parenchymateux temporal anterieur Déviation de l angle veineux cerebral La partie posterieure de la veine cérébrale interne et l ampoule de Galien (identifiée par son point de jonction avec la veine basilaire) se situe à nouveau sur la ligne médiane Le sinus longitudinal inferieur est egalement opacifié il présente une situation normale L artere cérébrale anterieure par contre ne présente aucune déviation laterale

B — *Region temporale*

Nos 23 cas de lesions temporales ont ete schematises dans le Tableau 2 Elles ont ete classees en lesions temporales anterieures posterieures et globales Sur les 11 cas de lesion temporale anterieure le phlebogramme profond a toujours ete deplace au dela de la ligne mediane et ce deplacement a toujours porte exclusivement sur sa portion anterieure Dans aucun des cas l artere cerebrale anterieure n a subi un deplacement superieur a celui du phlebogramme Sur les 3 cas de lesion temporale posterieure le phlebogramme a toujours ete deplace globalement donc dans ses portions anterieure et posterieure Sa translation laterale a cependant toujours ete plus marquee au niveau de la portion anterieure du phlebogramme profond La portion posterieure qui en etait deplacée correspondait soit a une partie de la grande veine de Galien soit a la portion terminale de la veine basilaire de Rosenthal Sur



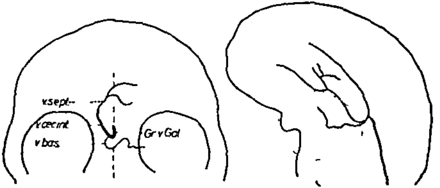
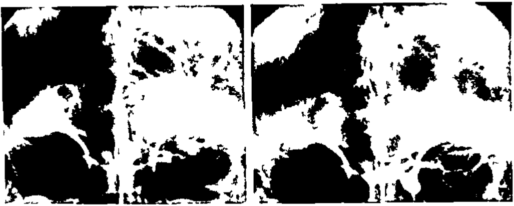


Fig 8 Cholesteatome temporal global Deviation latérale du phlebogramme profond dans son ensemble deviation marquée de la portion terminale de la veine de Rosenthal La tumeur occupant globalement la loge temrale entraine une déviation du phlebogramme antérieur et posterieur L amarre que constitue la jonction de l ampoule de Galien au sinus droit permet de comprendre la déviation légerement moins importante du phlebogramme posterieur

les 9 cas de lesion temporale globale le phlebogramme a toujours ete deplacé dans ses portions anterieure et posterieure, la portion posterieure l etant comme précedemment a un degre moindre Deux exemples que nous donnons ci apres permettent d illustrer ces constatations

1 *Hematome intra parenchymateux temporal antérieur* (Fig 7) Femme de 63 ans Il s agit d un hématome intra parenchymateux temporal antérieur qui a entrainé une déviation de l angle veineux cerébral La partie posterieure de la veine cérébrale interne et l ampoule de Galien (identifiée par son point de jonction avec la veine basilaire) se situe de nouveau sur la ligne médiane Le sinus longitudinal inferieur est également opacifié il a une situation normale L artere cérébrale antérieure par contre ne présente aucune déviation latérale

Ce cas est intéressant parce qu il permet de mettre en évidence une déviation latérale de la partie antérieure du phlébogramme profond alors que sa partie postérieure se situe a nouveau sur la ligne médiane et que l artere cérébrale antérieure n est absolument pas déplacée Il s agit donc d un exemple de localisation lésionnelle antérieure sans déviation de l artère cérébrale antérieure mais avec déviation du phlébogramme profond dans sa portion antérieure



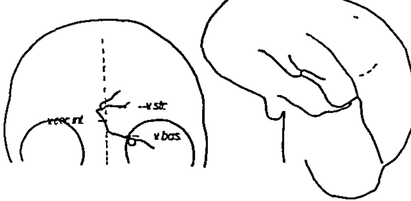


Fig 9 Méningiome pariétal haut Déviation du phlébogramme antérieur malgré la posit on poste rieure de la tumeur Celle-ci, un meningiome de la faux de situat on parasagittale et haute entraine sur le cliche de profil un abaissement du phlébogramme postérieur qui n est cependant pas dévié sur le cl ché de face Seul l angle veineux tres mobile est devié par la poussée tumorale à distance de 5 mm La tere cerebrale antérieure sub t une deviation de 6 mm

2 *Volumineux cholestéatome occupant toute la loge temporale* (Fig 8) Femme de 53 ans Il s agit d une énorme tumeur occupant la loge temporale dans toute son étendue Les portions ante rieure et postérieure du phlébogramme profond sont déviées vers l hémisphere opposé Ce pendant l angle veineux c est a-dire la portion antérieure du phlébogramme profond pré sente une deviation légèrement plus importante 15 mm que celle de la veine basilaire de Rosenthal avant son point d abouchement dans la grande veine de Galien (9 mm) L artere cérébrale antérieure présente une déviation de 12 mm

La poussée tumorale dans ce cas particulier s exerce autant sur le phlebogramme anterieur que postérieur Ce dernier cependant moins mobile dans le sens latéral que le phlébogramme antérieur présente de ce fait une déviation légerement moins importante

Il est intéressant de noter qu avant de se jeter dans l ampoule de Galien la partie terminale de la veine basilaire est l élément le plus devié de la portion postérieure du phlébogramme profond

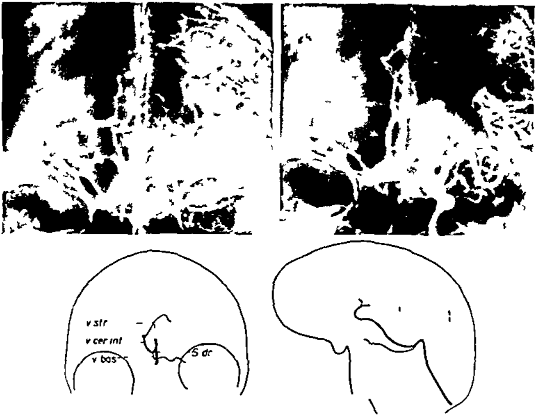


Fig 10 Glioblastome pariétal haut avec petite extension latéro-ventriculaire Déviation importante du phlebogramme anterieur (12 mm) alors que le phlebogramme postérieur (point d abouchement de la veine basilaire à l ampoule de Galien) n est deplace que de 3 mm Déviation aussi importante (13 mm) de l artere cerébrale anterieure

C — *Region parietale*

Les 16 cas de lesions parietales (Tableau 3) ont ete classes en lesions parietale haute ou parasagittale (7 cas), parietale basse ou latéro ventriculaire (7 cas) et parietale globale (2 cas) Pour les premiers le deplacement veineux a toujours ete present Deux fois seulement la partie posterieure du phlebogramme etait deviee au dela de la ligne mediane mais a un degre nettement moindre

Tableau 3

Lésions de la region pariétale (16 cas)

Localisation	Deplacement artériel superieure au déplacement veineux	Deplacement artériel identique au déplacement veineux	Deplacement artériel inférieure au déplacement veineux
Parietale haute (et para sagittale (7 cas)	1	1	5
Pariétale basse (7 cas)	1	1	5
Pariétale globale (2 cas)	0	0	2

que ne l'était sa portion antérieure. Pour les lésions pariétales basses en face du carrefour ventriculaire, les portions antérieure et postérieure du phlébogramme étaient déplacées à deux reprises même la portion postérieure du phlébogramme l'était davantage que sa portion antérieure. Dans les deux cas de lésion pariétale globale le phlébogramme était déplacé dans sa portion antérieure et postérieure, cette dernière cependant à un degré moindre. Les exemples que nous donnons ci-après permettent d'objectiver nos constatations.

1. *Région pariétale haute. Méningiome du 1/3 moyen de la faux* (Fig. 9). Femme de 40 ans. Il s'agit d'un méningiome du tiers moyen de la faux qui, bien que de localisation postérieure, entraîne une déviation de l'angle veineux (15 mm) alors que la partie postérieure du phlébogramme ne subit aucune translation latérale. L'artère cérébrale antérieure présente un déplacement de 6 mm.

La pression tumorale s'exerce dans ce cas de haut en bas et entraîne sur le cliché de profil un abaissement de la veine cérébrale interne et de l'ampoule de Galien; cette pression est cependant insuffisante pour dévier latéralement la portion postérieure de cette dernière, alors que la portion antérieure du phlébogramme, plus facile à mobiliser, est déplacée par la poussée à distance.

2. *Glioblastome pariétal haut* (Fig. 10). Femme de 61 ans, présentant un glioblastome avec une petite extension latéro-ventriculaire qui a entraîné une déviation importante du phlébogramme antérieur (12 mm) alors que le phlébogramme postérieur (point d'abouchement de la veine basilaire à l'ampoule de Galien) n'est déplacé que de 3 mm; de plus il y a une déviation tout aussi importante (13 mm) de l'artère cérébrale antérieure.

Cette tumeur pariétale haute sus-ventriculaire provoque surtout une poussée de haut en bas, poussée qui entraîne à distance un pivotement de l'angle veineux. La petite expansion latéro-ventriculaire entraîne par contre une pression latérale qui s'exerce sur le phlébogramme postérieur et le dévie légèrement.

Région pariétale basse. Épithéliome avec hématome intra-parenchymateux pariétal et latéro-ventriculaire (Fig. 11). Homme de 64 ans. Il s'agit ici d'un épithéliome atypique qui a entraîné un hématome intra-cérébral; le tout a provoqué une déviation latérale de l'ensemble du phlébogramme profond; la partie antérieure (avec l'angle veineux) est fortement refoulée (17 mm) vers l'hémisphère opposé, alors que la partie postérieure (avec la partie terminale et le point d'abouchement de la veine basilaire de Rosenthal) présente une déviation légèrement moindre (15 mm); quant à l'artère cérébrale antérieure, elle est déplacée de 18 mm. La tumeur se situe à peu près en dehors du carrefour ventriculaire et dévie fortement le phlébogramme postérieur. Le phlébogramme antérieur qui n'a pas d'amarre fixe présente une déviation légèrement supérieure.

Il est intéressant de noter que l'artère cérébrale antérieure est fortement déviée vers l'hémisphère opposé, bien que le processus occupant soit postérieur et profond. Cela va à l'encontre de la classique "dissociation artério-veineuse" habituellement admise.

D — *Région occipitale*

Nos 9 cas de processus occupant la région occipitale (Tableau 4) se répartissent de la façon suivante. Trois fois seulement la lésion était localisée exclusivement au pôle occipital; cinq fois le lobe occipital était débordé soit vers la ré

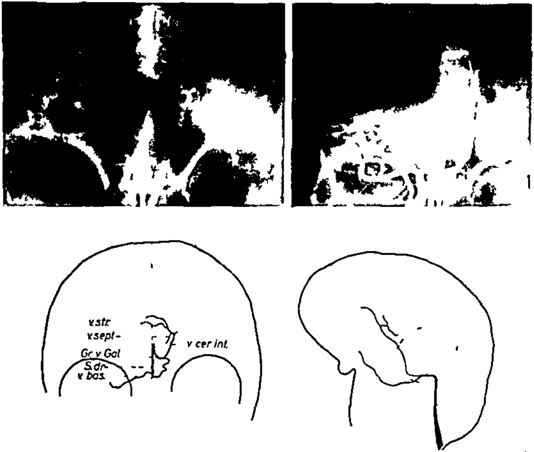


Fig 11 Métastase d un épithéliome atypique ayant entraîné un hématome intra cérébral profond pariétal bas Déviation latérale de l ensemble du phlébogramme profond La partie antérieure (avec l angl veineux) est fortement refoulée (17 mm) vers l hémisphère opposé La partie postérieure (avec la partie terminale et le point d abouchement de la veine basilaire de Rosenthal) présente une déviation légèrement moindre (15 mm) L artère cérébrale antérieure est déplacée de 10 mm

Tableau 4

Lésions de la région occipitale (9 cas)

Localisation	Déplacement artériel supérieur	identique	inférieur au déplacement veineux
Pole occipital (3 cas)	1	1	1
Occipito-temporale Occipito-pariétale Occipito-temporo-pariétale (6 cas)	1		4
Occipitale bilatérale	Ni déplacement artériel ni déplacement veineux		

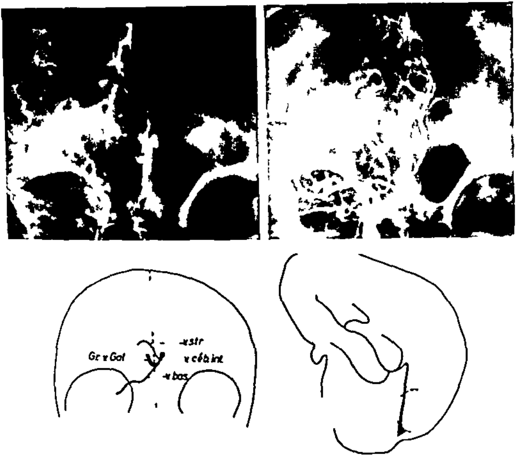


Fig 12 Épithéliome du pole occipital s insérant sur l angle formé par la tente du cervelet de la faux et de la du e mère de la convexité Deviation de 7 mm de l angle veineux alors que le phlébogramme posterieur se situe sur la ligne médiane L artère cerébrale anterieure est déviée de 12 mm

gion parietale, soit vers la region temporale, soit meme vers les deux a la fois une fois la localisation occipitale était bilaterale

Dans nos 3 cas de lesions exclusivement occipitales le phlebogramme pro fond etait déplace au delà de la ligne mediane Il intéressait toujours sa por tion anterieure avec une fois sa portion postérieure L artere cérebrale ante rieure était egalement chaque fois deplacee une fois son deplacement etait superieur a celui du phlebogramme (Fig 12) une fois il etait identique et une fois inferieur

Dans le cas de la lesion occipitale bilaterale il s'agissait d un hematome intra parenchymateux bilateral d apparition spontanee il n a existe ni deplace ment arteriel ni deplacement veineux

Dans tous les 5 cas de lesions occipitales etendues le phlebogramme profond a été devie au dela de la ligne médiane Ce deplacement interessait à deux

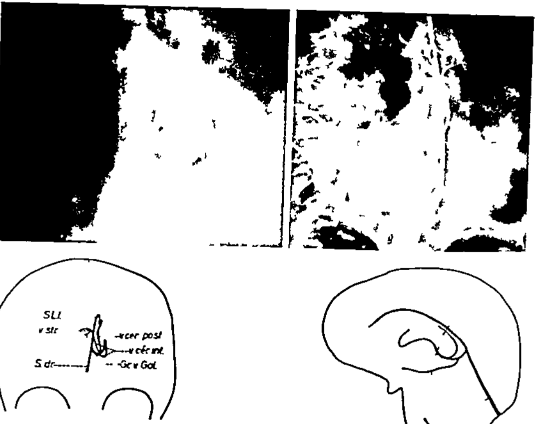


Fig 13 Astrocytome kystique temporo-occipito-pariétal Déviation importante du phlébogramme profond postérieur La veine cérébrale interne s éloigne de la médiane au fur et à mesure qu elle chemine vers l arrière Refoulement marqué de l ampoule de Galien et du trajet terminal de la veine basilaire de Rosenthal L angle veineux se situe presque sur la ligne médiane La veine cérébrale postérieure contournant le splenium du corps calleux est également fortement refoulée vers l hémisphère opposé

reprises la portion postérieure du phlébogramme, deux fois sa portion antérieure et une fois les deux ensemble Dans ce dernier cas la portion antérieure l était cependant davantage que sa portion postérieure Dans tous les 5 cas l artère cérébrale antérieure était également déplacée au delà de la ligne médiane cette déviation était cependant moins importante que celle du phlébogramme dans 4 cas et plus prononcée dans un cas

Les deux observations que nous reproduisons ci après concernant l une une lésion exclusivement occipitale et l autre une lésion occipito temporo pariétale

1 *Tumeur exclusivement occipitale* (Fig 12) Homme de 66 ans présentait un épithéliome du pôle occipital s insérant sur l angle formé par la tente du cervelet la faux et la dure mère de la convexité

Cette métastase a entraîné une déviation de 7 mm de l angle veineux alors que le phlébogramme postérieur se situe sur la ligne médiane L artère cérébrale antérieure est déviée de 12 mm

Il s agit d un nouvel exemple allant à l encontre de l opinion classique concernant la dissociation artério-veineuse Cette tumeur du pôle occipital et paramédiane entraine une poussée de l arrière vers l avant visible sur le cliché de profil (ou l ampoule de Galien est legerement refoulée vers l avant) C'est cependant la poussée à distance qui entraine la légere déviation laterale de l angle veineux qui non amarré pivote vers l hémisphère opposé Le phlébogramme postérieur bien amarre ne subit pas cette translation latérale qui s exerce cependant également sur l artere cérébrale antérieure qui n a pas elle d attache fixe

2 *Astrocytome kystique temporo-occipito-pariétal* (Fig 13) Enfant de 7 ans Il s agit d une volumineuse tumeur hémisphérique postérieure refoulant fortement le phlébogramme postérieur vers l hemisphère opposé Le phlébogramme profond est le plus dévié au niveau de la moitié postérieure de la veine cérébrale interne (20 mm) puis au niveau de la grande veine de Galien et enfin au niveau de la portion terminale de la veine basilaire de Rosenthal (16 mm) L angle veineux et le sinus longitudinal inferieur dans sa portion moyenne ne sont que légèrement déplacés L artère cérébrale antérieure présente un déplacement de 16 mm

La pression tumorale essentiellement hémisphérique postérieure entraine surtout du point de vue veineux une déviation du phlébogramme profond postérieur

Conclusion

Nous avons essayé de rappeler qu il etait possible dans les cas normaux de decomposer fréquemment ce phlébogramme profond en ses divers elements veineux qui ont éte groupés en systeme veineux médian et en systeme veineux latéral Grâce à ces deux systemes une portion anterieure et une portion posterieure peuvent etre reconnues au phlebogramme profond sur un cliche de face

Nous avons d autre part montre que ce phlebogramme profond vu de face présentait dans certains cas pathologiques des deformations pouvant contribuer au diagnostic topographique En effet, en cas de processus occupant l espace intra cranien, ce phlebogramme profond peut subir une déviation laterale par rapport a la ligne médiane C est cette translation latérale qui a seule éte envisagée dans cette étude

Il est habituellement admis qu un processus expansif n entraine pas ou n entraine qu un minime déplacement lateral du phlébogramme profond si ce processus siege dans une region hémispherique anterieure (alors que l artere cerebrale anterieure serait fortement deviée) Au contraire un processus occupant une region hémisphérique posterieure et surtout lorsqu il est profond provoquerait une deviation importante du phlébogramme profond (alors que l artere cerebrale antérieure ne serait que legerement deplacee)

En réalité nous avons constate qu il n en etait pas toujours ainsi et nous avons pu demontrer a l aide de certains exemples que le phlebogramme pouvait etre devie dans des cas de processus occupant les regions hemispheriques anterieure et postérieure Habituellement cependant en cas de localisation anterieure il existe une déviation de la portion anterieure du phlebogramme en cas de localisation posterieure elle est accompagnee d une déviation de sa portion posterieure

Nous avons d autre part essaye de demontrer que la dissociation arterio-

veineuse' est loin d'être constante et qu'elle est même parfois inverse En effet une tumeur de localisation antérieure peut dans certains cas entraîner une déviation moins importante de l'artère cérébrale antérieure que du phlébogramme (dans sa portion antérieure) et une tumeur de localisation postérieure peut entraîner une déviation aussi importante de l'artère cérébrale antérieure que du phlébogramme profond

Ce travail reposant sur l'étude de 83 phlébogrammes pathologiques et illustré par une série de clichés phlébographiques, doit donc simplement démontrer l'importance que peuvent revêtir dans certains cas particuliers les déformations de ce phlébogramme Celles-ci, considérées sous l'angle de la déviation latérale par rapport à la ligne médiane, peuvent fréquemment contribuer à localiser un processus occupant l'espace intra-cranien dans la région antérieure ou postérieure d'un hémisphère si on veut bien analyser et reconnaître les modifications des divers éléments du phlébogramme dans leur détail et non pas seulement dans leur ensemble

RÉSUMÉ

Les auteurs groupent les éléments du phlébogramme cérébral profond radiographié de face en un système veineux médian (veine du septum lucidum veine cérébrale interne ampoule de Galien veine cérébrale postérieure sinus longitudinal inférieur et sinus droit) et en un système veineux latéral (veine thalamo-striée et veine basilaire de Rosenthal) Ce phlébogramme peut être dévié par rapport à la ligne médiane dans sa portion antérieure ou dans sa portion postérieure selon que la lésion expansive intracranienne siège dans une région hémisphérique antérieure ou postérieure

SUMMARY

The authors group the venous components seen in the antero-posterior deep cerebral phlebogram into a medial venous system (vena septi pellucidi vena cerebri interna vena magna Galeni vena cerebri posterior sinus longitudinalis inferior and sinus rectus) and a lateral venous system (vena thalamo-striata and vena basalis of Rosenthal) An expansive hemispherical lesion depending on its situation may displace either of these parts laterally and the localization may thus be effected

ZUSAMMENFASSUNG

Die Autoren gruppieren die einzelnen Venen die auf dem anterior posterioren cerebralen Venogram sichtbar werden in eine mediale venöse Gruppe (vena septi pellucidi vena cerebri interna vena magna Galeni vena cerebri posterior sinus longitudinalis inferior and sinus rectus) und eine laterale Venengruppe (vena thalamostriata und vena basalis of Rosenthal) Diese Gruppen werden dann wieder in anteriore und posteriore Gruppen geteilt Ein raumbeengender Prozess kann je nach seiner Lage jede dieser Gruppen lateral verschieben Dies hilft um die Lokalisation des Prozesses zu bestimmen

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METASTATIC DISEASE TO THE BRAIN AND ITS DIFFERENTIAL DIAGNOSIS

by

ARNOLD BERRETT

Medical science has added materially to the human life span, thus increasing the number of individuals who live longer than 70 years Cancer tends to occur with increasing frequency with advancing age Thus metastatic disease to the brain has become more prevalent CUSHING s figure of 4 2 % is exceedingly low because it represents only cases in which the primary source had not been discovered More recent figures indicate that of all the intra cranial neoplasms both primary and secondary, metastases constitute at least 33 % Thus brain metastasis has become a major problem with the result that various workers have shown a new interest in this particular aspect of brain tumors

We have investigated over 100 cases known to have lesions in various primary sites In all of these, metastatic disease to the brain was suspected on clinical grounds The most common sites for the primary lesion are carcinoma of the lung in the male and carcinoma of the breast in the female Other less common sites of a primary source are gastrointestinal tract skin, kidney and thyroid Detailed studies of post mortem brains indicate that approximately two thirds of the cases reveal multiple metastatic deposits most of these situated supratentorially, and despite this fact the angiographic demonstration of multiple metastases is difficult A recent study by STRANG and MARSAN indicates that the absolute size of an intracranial lesion has an important





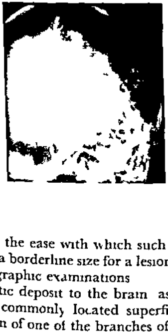


Fig 1 Primary mammary carcinoma Top view lateral large osteolytic area on left side Middle and lower view carotid angiography of same side vascular intracranial metastatic deposit associated with the large osteolytic area

bearing on the ease with which such a lesion is detected A diameter of 2 cm represents a borderline size for a lesion to be detected in neurologic and electroencephalographic examinations

Metastatic deposit to the brain as seen on arteriography is usually single and most commonly located superficially in the parietal lobe close to the termination of one of the branches of the middle cerebral artery As a general

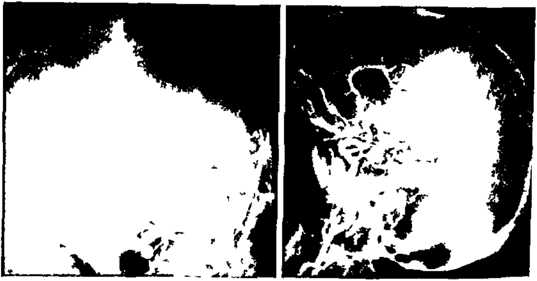


Fig 2 Primary carcinoma of cecum carotid angiography

rule, metastatic deposits are seen either in the vault of the skull or in the brain itself There are exceptions, e g the breast, which may show metastatic disease to both brain and skull (Fig 1)

Vascular architecture of metastatic deposits In general, it may be stated that the vascular architecture to some extent depends upon the nature of the primary tumor However, metastases for one type of primary tumor may have different appearances and metastases from different primary tumors may show angiographic similarities As the vascular changes vary within wide limits, it is usually not possible from the angiographic evidence alone to decide the nature of a primary tumor and thus make a specific diagnosis

The angiographic appearances of metastatic deposits may display any of the following features

1 Abnormal collection of vessels without any specific pattern (Fig 1)

2 Localized displacement of vessels with no abnormal vascularity (Fig 2)

3 Concentrically arranged bundles of delicate vessels at the periphery of the deposit No specific changes are demonstrated within the tumor, so that the central part is relatively avascular (Fig 3)

4 A fairly homogeneous almost circular, accumulation of contrast medium, which may resemble a meningioma

5 A distinct group exists where the lesion is small and the findings minimal In such cases it is often very difficult to tell whether one is dealing with a few partly filled tortuous vessels or a small metastatic deposit Additional pneumoencephalography is often of limited value



Fig 3 Primary pulmonary carcinoma right lateral carotid angiogram large rounded metastasis surrounded by vessels

Groups (1) and (2) represent the common appearances seen in the majority of our cases The variety described in group (4) is in our experience uncommon

It should be stressed that multiplicity is not of great value in the diagnosis of metastatic disease This is also found with meningiomas as well as with cerebellar hemangioendotheliomas There have also been reports of two distinct primary brain tumors e g glioblastoma multiforme and meningioma

Differential diagnosis

There is often an attitude of hopelessness, and as a result, a tendency to regard most cases of known primary cancer, with neurologic signs and symptoms as having metastatic disease to the nervous system With this in mind it is most important to take a searching look and view the entire patient because there are many unrelated conditions which present a similar clinical picture Also the problems encountered are frequently difficult and increased in complexity by multiple factors

Cerebral vascular disease The various types of vascular insufficiency constitute a common and important group of conditions to be considered in the differential diagnosis Since a similar age group is affected this presents a further difficulty Some aspects of these problems are exemplified by the following three cases

A 62-year-old man was seen by his local doctor because of vague mental symptoms. During the routine examination, which included chest radiography, a large, completely asymptomatic carcinoma of the lung was detected, and examination of the skeleton revealed an osteolytic area in the right parietal bone.

He was admitted to hospital with a diagnosis of carcinoma of the lung with metastatic involvement. Upon admission, because of some left sided neurologic signs, a right side carotid angiography was performed. This revealed severe vascular insufficiency. On the opposite side the major intracranial vessels were fairly well seen. The angiographic findings were subsequently confirmed at post mortem, at which time examination of the brain revealed no metastatic deposits.

A 55-year-old male had his left leg amputated because of a recurrent liposarcoma. He developed weakness of the left arm on the fourth postoperative day. The clinical diagnosis was metastatic disease to the brain. Carotid angiography, however, revealed complete occlusion of the right internal carotid artery close to its point of origin.

A 65-year-old woman presented with attacks of confusion, aphasia and right sided hemiparesis. Six years ago she received treatment for carcinoma of the cervix. Carotid angiography revealed severe kinking of the first portion of the left internal carotid artery.

Occasionally the combination of vascular occlusion and metastatic disease is found. Under the broad heading of vascular disease, we have examples of subdural hematoma, an aneurysm of the posterior communicating artery, and an arteriovenous malformation.

Medical problems. It should be stressed that there are a great number of common medical problems, in this group of cancer cases, which may or may not be related to the primary disease. They complicate the diagnosis and, in addition, may be responsible for confusing neurologic signs and symptoms. In general, it may be stated that these cases have a low 'cerebral reserve' and do not tolerate additional insults, no matter what the cause, such as the following:

Vascular disease;

Dehydration, fever, hypotension (protracted bed rest may reduce blood pressure to less than critical levels);

Liver failure with hypoglycemia, kidney failure with uremia;

Pituitary and adrenal insufficiency;

Bone marrow failure with anemia, tissue anoxia, bleeding tendency, which may result in subdural or intracerebral hematoma;

Cardiac and pulmonary insufficiency, e. g. hypertensive encephalopathy;

Drugs: sedatives (narcotics, analgesics and tranquilizers) and chemotherapeutic agents (e. g. nitrogen mustard in very large doses may be neurotoxic);

Electrolyte imbalance (e. g. hypercalcemia with osseous metastatic deposits).

Hypercalcemia may be present with lethargy, reflex changes and semi coma and thus may easily be mistaken for metastatic disease to the brain.

Primary intracranial tumor A woman of 61 presented with left sided hemiparesis of recent onset Sixteen years previously she had had a right sided radical mastectomy for carcinoma of the breast Metastatic disease to the brain was suspected Right sided carotid angiography was performed and an area of abnormal vascularity was demonstrated in the parietal lobe Because only a single lesion was found and the patient s general condition was good without any other evidence of disease elsewhere, an operative procedure was undertaken On histologic examination, the patient was found to have a glioblastoma multiforme The possibility of a second primary neoplasm must be considered because each new lesion is not necessarily a consequence of an existing cancer but may be an independent neoplasm

Neurofibromatosis A 54 year old man was being examined by his local doctor Chest radiography was performed as part of the routine examination A medium sized rounded lesion was noted in the right upper zone, and a smaller lesion in the right middle lobe He was admitted to the hospital with a diagnosis of metastatic disease to the lungs, and the gastrointestinal and urinary tracts were examined in a search for a primary lesion However, no abnormality was detected During the period of observation in the hospital, the patient complained of tinnitus in his right ear, associated with headache Skull roentgenograms revealed a destructive lesion in the region of the right petrous ridge and internal auditory meatus Pneumography showed dis placement of the fourth ventricle to the opposite side This was thought to be part of a metastatic process He was operated upon because of the urgency of the symptoms and histologic examination revealed this patient to have an acoustic neurinoma His right thoracic cage was finally explored and the lesions were found to be due to neurofibromatosis Incidentally, on closer inspection, the patient was noted to have cafe au lait spots

Infection Fungus or bacterial infection may occur in the cancer patient

Degenerative diseases Various demyelinating processes and degenerative conditions may be found Any part of the nervous system from the brain to the end organs e g muscle, may be involved without direct invasion of these tructures The effect on the nervous system is secondary or toxic

Chemotherapy using isolation infusion techniques (intra arterial) A catheter is threaded into an artery for protracted continuous intra arterial infusion to a tumor bearing area (regional chemotherapy) In one of our cases this method was employed in the treatment of an invading carcinoma of the right antrum Catheters were placed in both the external and internal carotid arteries It should be noted that a catheter left in a major vessel for any length of time may cause complications or accidents and compromise the circulation to a large

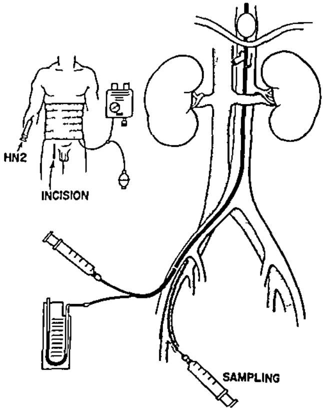


Fig 4 Balloon tipped catheter for occluding the abdominal aorta (Courtesy of WALTER LAWRENCE of the Surgical Department)

part of the brain Various other accidents such as air embolism and infection, have occasionally been encountered

In order to increase the concentration of the chemotherapeutic agent to the tumor bearing area, a balloon tipped catheter may be introduced into the abdominal aorta (Fig 4) By this method it is occluded and this temporarily excludes the tumor bearing area of the body from the general circulation This type of procedure causes alterations in the intracranial hydrodynamics

At the present time, this form of treatment is largely in the experimental phase, and we have had limited experience with it However, in the future, it may become a much more important and practical form of therapy Therefore complications will, occasionally, be encountered and should be included in any discussion of metastatic disease to the brain and its differential diagnosis

Conclusions

In the investigation of over 100 cases known to have lesions in various primary sites, metastatic deposits were demonstrated in approximately 40 %, and no definite abnormality detected in approximately 40 % of the cases The

latter group may well include small metastatic deposits, occlusion of minor vessels and miscellaneous toxic and metabolic diseases Our follow up information and post mortem material has been limited to date and we are therefore in no position thoroughly to evaluate this particular group Unrelated and unsuspected conditions were detected in approximately 20 % of our cases such as complete occlusion of the internal carotid artery and subdural hematoma

SUMMARY

The author states that the frequency of metastatic disease to the brain has increased A brief review is presented covering a material of over 100 cases with primary cancers of various sites and with signs and symptoms of metastatic disease Some angiographic appearances encountered in metastatic deposits to the brain are reviewed the differential diagnosis is discussed in detail and the importance of a complete examination of the patient is stressed

ZUSAMMENFASSUNG

Der Autor behauptet dass die Haufigkeit von metastatischen Erkrankungen im Gehirn zugenommen hat und prasentiert eine Übersicht uber 100 Falle von primarem Cancer von verschiedener Lokalisation mit den Zeichen und Symptomen von Metastasen Einige der angiographischen Bilder von Hirnmetastasen werden wiedergegeben und die Differentialdiagnose im Detail besprochen Den Patienten als eine Einheit zu betrachten wird hervorgehoben

RÉSUMÉ

L auteur pense que la fréquence des métastases cérebrales a augmenté et il fait une breve revue de plus de 100 cas de cancers primitifs de sièges divers presentant des signes physiques et fonctionnels de métastase cérébrale Il rappelle certains des caracteres angiographiques des métastases cérébrales et discute de façon détaillée leur diagnostic differentiel Il insiste sur l importance d un examen complet du malade

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CAROTID ANGIOGRAPHY IN THE DIAGNOSIS OF EXTRADURAL PARASELLAR TUMORS

by

NORMAN E CHASE and JUAN M TAVERAS

In the course of reviewing the angiographic changes in suprasellar tumors the authors found several extradural lesions that seemed to be adequately demonstrated by cerebral angiography (ref 1) It was also noted that those tumors without intradural components (with the exception of large chordomas) cause few, if any, changes in the encephalogram It was, therefore, decided to review a series of epidural tumors and other lesions to see the frequency and the accuracy with which cerebral angiography is capable of demonstrating them

Anatomy of the internal carotid artery The internal carotid artery enters the cranium through the carotid canal in the petrous bone in which it first ascends for a short distance It then makes a sharp medial bend and runs in a horizontal direction to the tip of the petrous bone This may be called the intrapetrosal segment (Fig 1) The completeness of the bony roof of the intra petrosal segment is variable in its medial portion The internal carotid artery is at least partially extra osseous and extradural before it reaches the petrous tip In the intrapetrosal segment the vessel leaves the carotid canal and enters the endocranial end of the foramen lacerum At the level of the petrous tip,



Fig 1 Normal submento-vertical cerebral arteriogram Intrapetrosal segment of internal carotid artery between → and →→ Intracavernous segment between →→ and →→ Posterior intracavernous segment of internal carotid artery is medial to anterior segment

the internal carotid artery bends sharply anteriorly and courses forward to the level of the dorsum sellae This portion may be termed the precavernous segment In this segment, the vessel lies in the relatively sparse areolar tissue at the base of the skull and is entirely extradural and extra osseous At about the level of the dorsum sellae the internal carotid artery enters the lumen of the cavernous sinus where it is contained until the next upward bend of the artery This is the intracavernous segment As the artery bends upward and slightly medial it passes medial to the anterior clinoid process where it emerges from the cavernous sinus Above the anterior clinoid process the artery turns upward and lateral up to its bifurcation This is the supraclinoid or supra cavernous portion

Slight variation in the shape of the curves described by the internal carotid artery in its intrapetrosal precavernous and intracavernous portions is the rule (Fig 2) A downward curve of the precavernous portion is not rare in normal cases The relationship of the intracavernous portion of the internal carotid artery with the floor of the sella turcica was studied in 100 normal arteriograms In 65 cases it was found to over lie the floor in only 3 cases was it found to be more than 3 mm above the floor



a



b



c

Fig 2 Normal lateral cerebral arteriograms common variations In all the intrapetrosal portion of the carotid artery roughly parallels the clivus as seen in the lateral projections

a) Intracavernous segment of internal carotid artery inferior to floor of sella turcica

b) Intracavernous segment of internal carotid artery projected over floor of sella turcica a most frequently found configuration

c) In this case the internal carotid artery is quite tortuous Despite the tortuosity of the carotid artery it projects over the floor of the sella at its midpoint The lack of correlation between tortuosity and arteriosclerosis is emphasized by the fact that the roentgenogram represents a patient aged 12

The internal carotid artery gives origin to tiny branches supplying the dura in its precavernous portions as well as the caroticotympanic branches in the carotid canal (ref 4, 5) Because of the extensive extradural course of the carotid artery and because of its proximity to the sphenoid sinus, nasopharynx, foramen ovale and sella turcica it would be expected that a tumor arising in these structures should cause displacement of the internal carotid artery before any significant displacement of the intradural structures may be seen In ad

Table 1

Extradural tumors

	Histologically proven	Clinical and radiographic data only
Pituitary adenoma	6	9
Meningioma	7	6
Chordomas	5	0
Carcinoma of nasopharynx	0	4
Chondrosarcoma	1	0
Meningocoele	1	0
Nasal angiofibroma	1	0
Metastatic carcinoma	0	1
Osteogenic sarcoma (Biopsy report Osteogenic sarcoma arising in sphenoid sinus However long term survival following radiation therapy makes histologic diagnosis questionable See Fig 6 c and d)	1	0
Total	22	20

dition, vascular tumors in the region of the internal carotid artery may cause enlargement of some of the tiny branches supplying the dura to a degree allowing angiographic demonstration Normally these branches are not visible on the angiogram

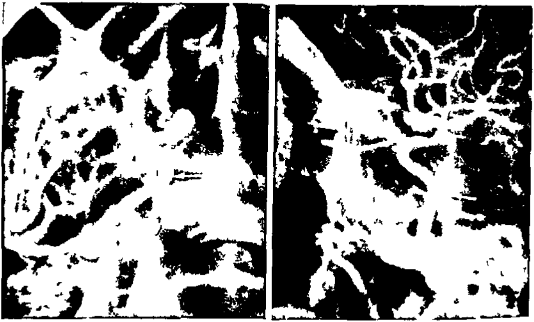
Pathologic features and classification of tumor material

As with suprasellar tumors in this region pituitary adenomas make up the bulk of extradural tumors in the region of the sella turcica (ref 1) (Table 1) Fifteen of the cases in this series were pituitary adenomas Although there have been verified cases of extradural extension of pituitary adenomas in the literature, it is most unusual to remove the base of the skull at routine post mortem examination and the standard intracranial surgical approach to pituitary adenomas does not permit study of extradural extension (ref 3) It should be

Table 2

Extradural tumors

Age	Females	Males
Under 31	1	2
31—40	2	5
41—50	5	6
51—60	8	7
61 and over	4	2
Total	20	22



a b

Fig 3 Case of 51 year-old female Entirely extradural meningioma proven by autopsy a) Submento-vertical arteriogram Lateral displacement of intracavernous segment of internal carotid artery clearly apparent its posterior portion (arrow) is most laterally displaced (cf fig 1) Irregularity of the wall of the carotid suggests direct invasion by tumor (histologically proven) b) The lateral arteriogram reveals only slight elevation of intracavernous segment of carotid artery above the floor of sella turcica although irregularity of carotid wall and presence of small vessels arising from internal carotid artery (→) are striking Enlargement and downward displacement of ophthalmic artery (↠) suggesting extension of tumor into orbit

apparent, therefore, that available statistics of extradural extension of pituitary tumors are not representative of the true figure

Meningiomas with extradural components make up 12 of the cases in this series

Third in frequency are the carcinomas of the sphenoid sinus and nasopharynx both primary and secondary There are 6 cases in this series

Chordomas are next in frequency with 5 cases

A single case of parasellar meningo encephalocoele is included in this series

Neuromas, primarily of the 5th nerve may present as extradural or partially extradural tumors, although there are none in this series

Extradural aneurysms of the carotid artery and glomus jugulare tumors may present in the same area These are not included in this series as these lesions rarely offer problems in angiographic diagnosis

It will be noted that 20 cases did not have histologic verification Biopsy or resection was attempted whenever possible, but when the lesion was considered surgically inaccessible, and the clinical and radiographic criteria adequate,



Fig 4 Case of 53 year-old male Parasellar extradural chordoma histologically verified Forward and downward displacement of intrapetrosal segment of internal carotid artery (←) Intracavernous segment accordioned forward (↔) Middle meningeal artery (→) bowed posteriorly by tumor



Fig 5 Case of 48 year-old female Extra and intradural parasellar meningioma verified at operation Intracavernous portion of the internal carotid artery (→) is displaced medially and so is the supraclinoid portion (↔)

the patients with malignant tumors were given radiotherapy and the final diagnosis based on significant response to radiotherapy and follow up examination In certain cases biopsy and/or autopsy were refused by the patient or his family In suspected carcinomas of the nasopharynx and sphenoid sinuses at least *one attempt and usually more than one, was made to obtain* histologic verification There are 22 males and 20 females in this series Most of these patients are in the 5th and 6th decades (Table 2)

Radiographic findings

Internal carotid artery The precavernous and intracavernous portions of the internal carotid artery may be displaced laterally, medially or upwards or they may be compressed and sometimes invaded Extradural tumors that arise or invade the skull medial to the precavernous portion of the internal carotid artery may cause lateral displacement and elevation of that segment (Figs 3 and 7a) Tumors which extend extradurally may cause downward displacement of the precavernous segment although this displacement may be difficult to evaluate (Fig 4) Tumors arising lateral to the precavernous portion of the internal carotid artery may cause medial displacement of that vessel (Fig 5)

Elevation of the intracavernous segment of the internal carotid artery implies extradural extension and elevation of the cavernous sinus (Fig 6) This should not be confused with relative elevation of this segment of the



a



b

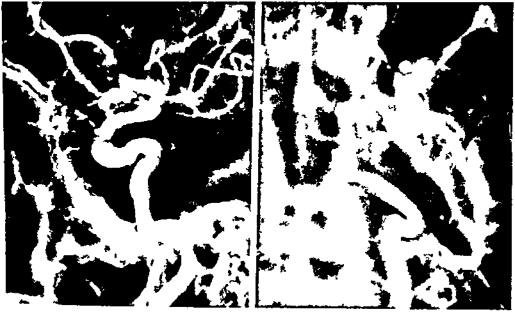


c



d

Fig 6 a) Case of 49-year-old female Primarily extradural pituitary adenoma location proven at operation. Marked elevation of intracavernous segment of internal carotid artery and posterior displacement of distal intrapetrosal segment (arrow) b) Case of 66-year-old man Suspected pituitary adenoma (history and response to radiotherapy strongly suggested pituitary chromophobe adenoma) Convex upward displacement of intravenous segment of carotid artery (arrow) commonly seen with extradural extension of pituitary adenoma. c) Case of 23-year-old man with histologic diagnosis of osteogenic sarcoma of sphenoid sinus Extreme elevation and posterior displacement of the intracavernous segment of internal carotid artery (arrow) d) Same case as in (c 5 years later after a course of radiation therapy to the sphenoid sinus More normal position of intracavernous segment of carotid artery and dense remineralization of medial sphenoid



a b

Fig 7 Case of 57 year-old man Pituitary adenoma verified at operation (No clinical evidence of extradural invasion by tumor) a) Marked destruction of the sella turcica with no evidence of elevation of intracavernous segment of internal carotid artery b) Intracavernous segment of internal carotid artery displaced laterally the lateral displacement of the posterior portion of the intracavernous segment is more marked than is usual in cases of pituitary tumor

internal carotid artery occurring frequently in intrasellar tumors causing enlargement of the sella turcica and depression of the floor of the sella (Fig 7a) Lateral displacement of the intracavernous segment is a diagnostic sign of an expanding intrasellar mass and does not necessarily indicate extradural extension (ref 1) (Fig 7b)

Medial displacement of the intracavernous portion of the carotid artery suggests a tumor lateral to the sella turcica with an extradural component

Direct involvement of the wall of the internal carotid in its pre or its intracavernous segments, as evidenced by narrowing irregularity of contour and sometimes occlusion, is absolute evidence of extradural extension (Fig 8) Direct involvement of the wall of the carotid artery occurs almost exclusively with meningiomas and may readily be differentiated from the irregularity of the vessel wall caused by arteriosclerotic placques The angiographic demonstration of the tiny branches of the pre and intracavernous portions of the internal carotid artery, not usually visible signifies dural invasion by the tumor This again occurs usually with meningiomas (Figs 3 and 9) (ref 4, 5)

Other vessels involved The middle meningeal artery enters the calvarium at the base of the skull via the foramen spinosum and lies extradurally in the



Fig 8 Case of 69 year-old female with strongly suspected parasellar meningioma Marked involvement of the wall of the intracavernous and supraclinoid portions of the internal carotid artery (Direct invasion of internal carotid artery occurs most often with meningiomas)



Fig 9 Case of 48 year-old female Parasellar meningioma verified at operation Narrowing and irregularity of the wall of intracavernous portion of internal carotid artery secondary to invasion by tumor as well as enlarged dural branches of the carotid artery supplying the tumor (arrow)

floor of the middle fossa during part of its course This portion of the middle meningeal artery may therefore be elevated and stretched by tumors invading or arising in the base of the skull (Fig 4)

The posterior displacement of the basilar artery by tumors arising at the base of the skull is well known and will not be dealt with here, but it is worth while pointing out that the basilar artery is intradural in location and its elevation and posterior displacement are not specific for extradural tumors

The ophthalmic artery may be displaced by extradural parasellar tumors invading the orbit (Fig 3) (ref 2)

Occasionally extensive tumors involving the base of the skull may occlude one or both internal jugular veins and secondary venous pathways may be seen (Fig 10) Occlusion of the cavernous sinus due to invasion by tumor may also occur, but this cannot be diagnosed by angiography with accuracy, although it may be suspected by the pattern of venous return

Conclusions

Extradural tumors in the region of the sella turcica frequently offer a challenge to clinical diagnosis Slight changes may be seen on the conventional films of the skull, which are not diagnostic unless destructive bone lesions are evident Invasive tumors of the base of the skull are extremely hazardous to



Fig 10 Same case as in fig 4 Complete absence of both jugular veins and enlarged collateral venous channels (arrows) bilaterally strongly suggest obstruction of internal jugular veins by extensive chordoma involving entire base of skull

attack by intracranial approach and are usually unresectable Biopsy of invasive nasopharyngeal and sphenoid sinus tumors is notoriously difficult and it is frequent to fail to obtain histologic proof after multiple biopsies even in tumors exhibiting extensive bone destruction

Extradural tumors in the parasellar region excepting the very large ones usually do not cause enough distortion of intradural structures to permit accurate diagnosis on the basis of encephalography and do not distort sufficiently the intraarachnoidal vasculature

Because the greatest extent of the internal carotid artery in the calvarium is extradural it is apparent that relatively small extradural tumors adjacent to the carotid may cause significant displacements The involvement of the vessel wall by tumor or the development of abnormal tumor vessels arising from the pre or intracavernous portions of the carotid artery is virtually pathognomonic of tumor that is at least in part extradural or involves the dura at the base or in the tentorium

The middle meningeal artery may be displaced from its course at the base of the skull by an extradural tumor and invasion of the orbit may cause displacement of the ophthalmic artery

Extensive extradural tumors may occasionally cause occlusion of one or both internal jugular veins It is, therefore, apparent that when extradural involvement by tumor in the parasellar region is considered, cerebral angiography offers considerable help for an accurate diagnosis to be made

SUMMARY

Thirty cases of parasellar extradural tumors were studied by means of carotid angiography fifteen of which had also had encephalography Small extradural tumors without intradural extension could not be diagnosed by encephalography Relatively small extradural tumors can cause displacements of the extradural portions of the carotid siphon Occasionally a specific histologic diagnosis can be made on the basis of angiographic changes Tumors in this region include nasopharyngeal carcinomas meningiomas and chordomas as well as pituitary tumors with extradural extension

ZUSAMMENFASSUNG

Dreissig Falle von extraduralen parasellaren Tumoren wurden mittels Carotisangiographie studiert In 15 von diesen 30 Fallen wurde ausserdem eine Encephalographie vorgenommen. Kleine extradurale Tumoren ohne intradurale Ausbreitung konnten mittels Encephalographie nicht diagnostiziert werden Relativ kleine extradurale Tumoren konnen Verdrangungen der extraduralen Strecke des Carotissiphons verursachen Gelegentlich kann eine histologische Diagnose gestellt und mit den angiographischen Veranderung in Einklang gebracht werden Zu den Tumoren dieser Region gehoren Nasopharynxcarcinome Meningeome und Chordome wie auch Hypophysentumoren mit extraduraler Ausbreitung

RÉSUMÉ

Les auteurs ont examiné par angiographie carotidienne trente cas de tumeurs extradurales parasellaires dont quinze avaient aussi subi une encéphalographie L encéphalographie n a pas permis de déceler les petites tumeurs extradurales qui n avaient pas d extension intradurale Des tumeurs extradurales relativement petites peuvent déplacer les part es extradurales du siphon carotidien Les signes angiographiques permettent parfois de faire le diagnostic de nature histologique Les tumeurs de cette région comprennent les cancers nasopharyngiens les méningiomes et les chordomes ainsi que les tumeurs hypophysaires qui ont une extension extradurale

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TEMPORAL TUMORS STUDIED BY SERIAL ANGIOGRAPHY — A REVIEW OF 150 CASES

by

NORMAN E CHASE and JUAN M TAVERAS

A great deal has been written about the angiographic diagnosis of temporal tumors and the characteristic angiographic changes encountered have been described in a number of authoritative articles and reference texts (ref 1, 3 4 and 5) However, most of these descriptions are those of the static anatomical changes seen with temporal tumors The additional information gained from the pathologic physiologic conditions that can be deduced from serial angiography will now be reported In view of the large amount of pathologic material examined by serial angiography, available to the authors it was felt that a re-evaluation and review of the findings was indicated at this time

Material The material consisted of 150 unselected cases from a group of approximately 300 temporal tumors, all diagnosed by means of serial angiography The total number of supratentorial tumors diagnosed with serial angiography in the same period (1935—1961) was 1 100, an incidence of 27 % for temporal tumors Frontal as well as lateral roentgenograms were obtained in all cases, covering a total of 7 sec of circulation time in cases without clinical evidence of increased pressure and 9 or 10 sec in those with evidence of elevated intra cranial pressure Except in special situations the first 6 films were made at 0 5 sec intervals and the rest at 1 0 sec intervals Simultaneous anteroposterior and lateral serial series were made in about two thirds of the cases and in the same number an automatic injector was used

In this group, 118 were intracerebral and 32 extracerebral In the extra cerebral group, meningiomas made up the vast majority and in the intracerebral group gliomas predominated (Tables 1 and 2) There was a total of 75

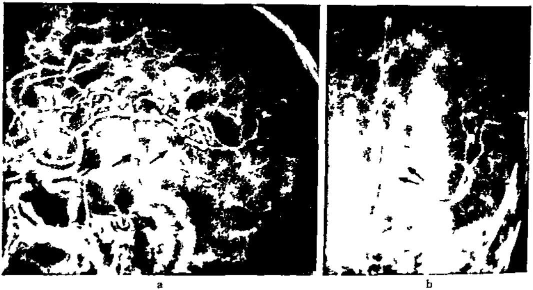


Fig 2 a) Surgically verified temporal lobe glioma in a 35 year old man The temporal branches of the middle cerebral artery (arrows) are stretched over the temporal lobe which is expanded by the intracerebral tumor The most marked elevation of the middle cerebral artery is in its proximal portion The usual downward and anterior dip of the proximal portion of the middle cerebral artery is eliminated These findings suggest that the tumor primarily involves the anterior portion of the temporal lobe b) Histologically proven malignant glioma in a 38 year old male involving primarily the anterior temporal lobe The knee of the middle cerebral artery (arrow) is elevated and displaced toward the mid line The horizontal portion of the middle cerebral artery (medial to the knee) is elevated above the bifurcation of the internal carotid artery The proximal portion of the posterior cerebral artery is stretched medially (2 arrows) by the tumor expanding the temporal lobe c) Same case as in (b) Striking elevation of the basilar vein (arrow) by the anterior temporal lobe glioma

ment was exceeded in only 6 of 100 normal arteriograms reviewed in this study

2 '*Angiographic sylvian point* A point at which the last main branches of the middle cerebral artery leave the end of the insula to reach the surface of the brain This point may be identified on the a p films as the point where the middle cerebral trunks take the last sharp bend towards the inner table of the skull This point may also be identified in the lateral film where the last middle cerebral branches are seen in cross section (Fig 1) The 'angiographic sylvian point is usually no more than 4 2 cm from the inner table of the skull as meas



Fig 3 Surgically proven intracerebral ependymoma in a 1? year-old male The tumor was centered in the posterior portion of the temporal lobe a) The angiographic sylvian point (arrow) is displaced towards the midline The anterior portion of the middle cerebral artery is in relatively normal position The posterior communicating and proximal posterior cerebral arteries (2 arrows) are medially displaced This is a frequent finding in temporal tumors without deep extension b) The upward displacement of the middle cerebral artery is most marked at the angiographic sylvian point (arrow) there is forward displacement of this point these findings are consistent with posterior temporal tumors The downward displacement of the anterior choroidal (2 arrows) and posterior cerebral artery (3 arrows) are consistent with the intracerebral location of the tumor

ured on a p films This measurement was exceeded in only 4 of 100 normal angiograms and has no relationship to the skull size

3 '*Knee of middle cerebral artery* The point where the middle cerebral artery enters the sylvian fissure and may be identified on a p and lateral films as the point where the middle cerebral artery reverses its initial downward dip and proceeds superiorly and posteriorly (Fig 1) This is the usual site of the bifurcation or trifurcation of the middle cerebral artery The knee of the middle cerebral artery usually measures less than 3 0 cm from the inner table of the skull as seen on a p films This limit was exceeded in 8 of 100 normal angiograms

4 '*Draping*' of the temporal branches of the middle cerebral artery is the downward and posterior course of the middle cerebral branches as they proceed on their course on the outer surface of the temporal lobe (ref 3) (Fig 2a) This is usually present in intracerebral tumors In extracerebral tumors these branches are usually elevated along with the temporal lobe and no draping is evident

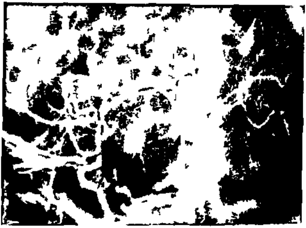


Fig 4 Autopsy proven deep extension of malignant glioma of temporal lobe in a 33 year old female Marked elevation of the middle cerebral artery seen on the lateral film although no corresponding degree of medial displacement of the middle cerebral artery was apparent in the a p films The anterior choroidal artery (3 arrows) is stretched and the posterior communicating artery (arrow) is depressed There is also draping of the temporal branches of the middle cerebral artery

Differential diagnosis

Differentiation of anterior from posterior temporal tumors Anterior temporal tumors tend to elevate the horizontal portion of the middle cerebral artery as noted in a p films (Fig 2b) The knee of the middle cerebral artery is usually more than 3 0 cm from the inner table of the skull as seen in a p films, and the proximal portion of the middle cerebral artery is generally elevated more than 1 0 cm above the clino parietal line as noted on the lateral film The basilar vein is usually displaced medially and may be elevated (Fig 2c) The superficial temporal vein may be elevated more than 2 2 cm above the clino parietal line as seen on the lateral films This measurement was exceeded in 5 of 100 normal angiograms The superficial temporal vein was visible in 70 of the 100 normal cases

Posterior temporal tumors elevate the 'angiographic sylvian point and the distal portions of the middle cerebral artery more than 1 0 cm above the clino-parietal line as seen in the lateral films (Fig 3) The angiographic sylvian point will be seen to be more than 4 2 cm from the inner table of the skull on the a p films Posterior extension of posterior temporal tumors is a relatively common finding In such instances the angiographic sylvian point will be displaced anteriorly (Fig 3) This may be determined if the angiographic sylvian point is forward of the halfway point of the clino parietal line Associated telescoping of the middle cerebral posterior cerebral and/or anterior choroidal arteries may be seen in these cases

Determination of deep extension of intracerebral temporal tumors Deep extension of intracerebral temporal tumors may be determined by the following criteria

1 Elevation of the middle cerebral artery as seen on the lateral film without significant medial displacement of the insula (i e medial displacement of the 'angiographic sylvian point knee of the middle cerebral and intervening middle cerebral artery (Fig 4)



a b

Fig 5 Autopsy proven malignant glioma with extension into the basal ganglia and brain stem in a 67 year-old female a) The anterior choroidal artery (3 arrows) is stretched and displaced laterally The lenticulostriate arteries (arrows) are more prominent than normal and show some lateral displacement in their more distal portions b) Disproportionate elevation of the middle cerebral artery compared with the relative lack of medial displacement in the a p film The anterior choroidal artery (arrow) is seen to be stretched and elongated The posterior communicating and posterior cerebral artery (2 arrows) (not so well seen in the a p films) is seen to be displaced inferiorly and stretched This as noted before is an indication of the intracerebral location of the tumor

2 Lateral and inferior displacement of the distal portions of the anterior choroidal artery (Fig 5)

3 Lateral displacement and enlargement of the distal portions of the lenticulostriate arteries (Fig 5) The lenticulostriate arteries may also be displaced medially if the bulk of the tumor is lateral to these vessels

4 Inferior and occasional lateral displacement of the posterior cerebral artery (Fig 4)

5 Opening of the angle between the thalamostriate vein and the internal cerebral vein as demonstrated on the lateral film greater than can be accounted for by the elevation of the thalamostriate vein as seen on the a p films (Fig 6) (ref 2)

6 Opening of the angle between the basilar vein and the internal cerebral vein and depression of the posterior portion of the basilar vein as seen on the lateral films (Fig 6) (ref 2)

7 Increased rounding of the posterior portion of the internal cerebral vein as seen on the lateral films (Fig 6) (ref 2)

8 Early deep venous drainage either through normal venous channel or abnormal tumor veins

9 Deep location of abnormal tumor circulation

By utilizing the above criteria the presence or absence of deep extension of tumor was correctly established in 9 of the 10 autopsy cases

Differentiation of intracerebral from extracerebral tumors Draping of the [illegible] branches of the middle cerebral artery was present in all but one [illegible]

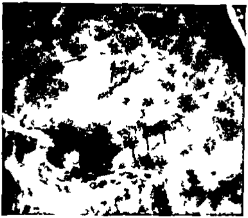


Fig 6

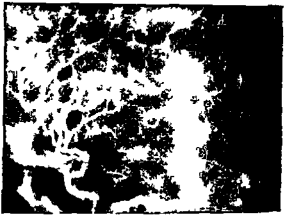


Fig 7

Fig 6 Venous phase of angiogram in a 40-year-old male with histologically verified malignant glioma clinical and surgical evidence of deep extension of tumor Internal cerebral vein (2 arrows) arched posteriorly and more rounded than normal angles between thalamostriate vein (arrow) and internal cerebral vein and between internal cerebral vein and basilar vein (3 arrows) are more obtuse than normal

Fig 7 Surgically removed meningioma arising from the tentorial attachment in a 36 year old femal The temporal branches of the middle cerebral artery are elevated by the extracerebral tumor Enlarged posterior branch of the middle meningeal artery (arrow) supplies the tumor

intracerebral tumors in this series The temporal branches of the middle cerebral artery will be elevated along with the temporal lobe by all but medially placed extracerebral tumors (Fig 7)

The anterior choroidal artery was seen in 116 of the 150 cases studied and was found to be elevated in all of the antero medially placed extracerebral tumors (Fig 8) It was usually not displaced medially in these cases The anterior choroidal artery may be elevated in intracerebral temporal tumors where the tumor is primarily inferior to the temporal horn and also where there is dilatation of the temporal horn secondary to obstruction by tumor In cases where the bulk of the intracerebral tumor is superior to the temporal horn the anterior choroidal artery is depressed In all cases of intracerebral temporal tumor the anterior choroidal artery is displaced medially This implies present or imminent uncal herniation

The posterior communicating artery was demonstrated in 70 of the cases in this study and there was good to excellent outlining of the posterior cerebral artery in 37 of the 70 The posterior communicating and posterior cerebral arteries are elevated by medially placed extracerebral tumors and may be displaced laterally In all intracerebral cases in this series, with demonstration of the posterior communicating and posterior cerebral arteries, depression and medial displacement was noted (Figs 3, 4 5 and 9)

Good to excellent outlining of the basilar vein was noted in 108 cases in this series Medial displacement of the vein was noted in all of the intracerebral tumors Elevation without medial displacement is the usual pattern in medially



Fig 8 Surgically proven meningioma arising from medial and anterior aspects of the floor of the middle fossa in a 57 year-old female Marked elevation of anterior choroidal artery (2 arrows) by this extracerebral tumor Enlarged abnormal meningeal vessels arising at posterior portion of the intracavernous segment of the internal carotid artery (arrow) supply a portion of the tumor

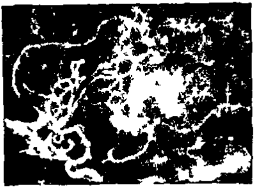


Fig 9 Histologically proven malignant glioma in a 40 year-old female Downward displacement of the posterior communicating and posterior cerebral arteries (2 arrows) as well as suggested slight downward displacement of the anterior choroidal artery (arrow) Draping of the temporal arteries characteristic of intracerebral temporal tumor

placed extracerebral lesions Elevation of the vein was seen in 31 of the intracerebral lesions with outlining of the basilar vein All of the other intracerebral cases exhibited downward displacement or no apparent upward or downward shift

Abnormal tumor vasculature was seen in 54 cases in the study The abnormal vasculature was considered of type specific in 29 instances In the other 25 cases associated findings such as an early draining vein or source of feeding arteries assisted in the diagnosis

An early draining vein was seen associated with abnormal tumor vasculature in 29 cases An early vein unassociated with tumor vasculature was seen in 10 cases The early veins were associated in all instances with intracerebral lesions Slowing of local arterial circulation was present in 3 cases and slowing of local venous circulation was present in 1 case These findings were all in intracerebral lesions

Using the above criteria, all of the histologically verified extracerebral tumors were correctly diagnosed and 98 % of the histologically verified intracerebral tumors were correctly diagnosed

Advantages of serial angiography

In addition to the obvious advantage of having arterial intermediate and venous phases in all cases irrespective of the circulation time serial films enable evaluation of dynamic changes not appreciated if only two or three films are available

Local slowing or speeding of circulation time helped establish a diagnosis of tumor in 43 cases These changes culd be overlooked if only single film or two or three film techniques were used

The anterior choroidal artery and posterior communicating and posterior cerebral arteries are extremely useful to differentiate intracerebral from extra cerebral tumors These vessels were seen on only one or two films of the series in 63 cases for the anterior choroidal and 38 cases for the posterior com municating artery It is apparent that this 'flash filling of these vessels might be missed if serial films were not obtained In 54 of the cases with abnormal tumor vasculature the contrast filling was very transient or atypical in 25 cases In these instances the abnormal vasculature may not have been seen or the associated findings necessary for correct diagnosis (i e early venous drainage) may have been missed if 2 or 3 film techniques had been used

Because of the differential in speed of flow of the internal carotid and exter nal carotid circulation, it is possible to obviate the need for separate internal and external carotid punctures if serial angiography is performed

Discussion

The criteria for the angiographic diagnosis of anterior temporal intracere bral tumors is the elevation of the horizontal portion of the middle cerebral artery, medial displacement of the knee of the middle cerebral artery (more than 30 mm from the inner table of the skull), elevation of the proximal portions of the main branches of the middle cerebral artery more than 1 0 cm (1 5 cm in children) above the clino parietal line' and stretching and 'drap ing of the temporal branches of the middle cerebral artery The anterior choroidal and posterior communicating arteries tend to be depressed and dis placed medially in intracerebral anterior temporal tumors The basilar vein is usually displaced medially with these lesions but may not be elevated The superficial sylvian veins will usually be elevated more than 22 mm above the clino parietal line

Extracerebral anterior temporal tumors may be differentiated by their tendency to elevate the anterior choroidal and posterior communicating ar teries if medial in location, and tendency to elevate the temporal branches of the middle cerebral artery if laterally placed

Posterior temporal tumors elevate the more distal branches of the middle cerebral artery and cause medial displacement of the angiographic sylvian point (greater than 42 mm from the inner table) Retrosylvian extension may cause anterior displacement of the angiographic sylvian point Profound 'draping of the temporal branches may be seen in posterior temporal intra cerebral tumors although medial tentorial meningiomas may cause similar changes Stretching of the anterior choroidal artery and medial and inferior displacement of the posterior cerebral artery imply intracerebral location of the mass (although in some cases it may be due to hippocampal herniations accompanying an extracerebral lesion) Posterior temporal intracerebral tu mors have a greater tendency to invade deep structures than do anterior tem poral tumors Deep extension may be determined by opening of the venous

angle, elevation of the posterior portion of the internal cerebral vein, rounding of the angle between the basilar and internal cerebral veins and downward or outward displacement of the basilar vein Enlargement and lateral displacement of the lenticulostriate arteries also implies deep extension of tumor Early deep venous drainage is presumptive evidence for deep extension of tumor

Posterior temporal extracerebral tumors will elevate the temporal branches if laterally placed and will elevate the posterior cerebral artery and basilar vein if medially placed Medial tentorial meningiomas will also tend to displace the posterior cerebral artery laterally

Speeding or slowing of the circulation was present in 27 % of the cases in this study It is evident that these important findings may be missed in non serial angiographies

Using the criteria outlined in this paper, it was possible correctly to determine whether the tumor was intra or extracerebral in 98 % of these cases Deep extension was correctly designated in 90 % of those with autopsy verification

SUMMARY

A material of 150 temporal tumors studied by serial carotid angiography were reviewed The angiographic changes were evaluated for means of determining deep extension of tumor and whether the tumor was intra or extracerebral in origin A correlation was made with clinical pneumographic operative and pathologic findings

ZUSAMMENFASSUNG

Hundertfunfzig serienangiographisch untersuchte Temporallappentumoren wurden durchgesehen Die angiographischen Veranderungen wurden mit Hinsicht auf die Tiefenausdehnung und der Entscheidung des intra oder extracerebralen Ursprungs des Tumors ausgewertet Die klinischen pneumographischen operativen und pathologischen Befunde wurden korrelliert

RÉSUMÉ

Les auteurs ont revu un groupe de 150 tumeurs temporales étudiées par angiographie carotidienne en série Les modifications angiographiques ont été étudiées comme moyen d apprecier l extension en profondeur et l origine intra ou extracérébrale des tumeurs Ils ont établi une confrontation entre les signes cliniques pneumographiques per-operatoires et anatomo pathologiques

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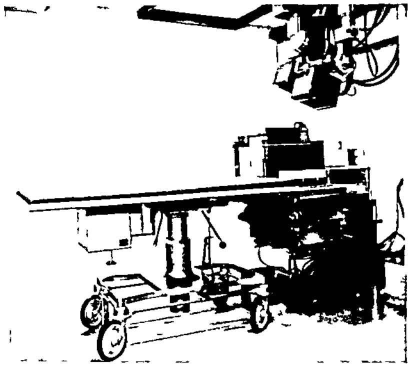
SIMULTANEOUS BIPLANE STEREO SERIAL CEREBRAL ANGIOGRAPHY — A NEW APPARATUS

by

NORMAN E CHASE and JUAN M TAVERAS

It is a generally accepted fact that stereoscopic films may be helpful in the evaluation of complex anatomical details There is also little doubt that stereoscopic angiographic studies may be of assistance particularly when investigating intracranial arterial aneurysms Many techniques have been devised for obtaining stereoscopic angiographic films These have usually utilized either two separate injections with a tube shift between injections or they have involved a mechanism for shifting the roentgen tube between exposures, or involved double anode roentgen tubes These methods have usually been rather complicated or the apparatus has been much too expensive for general use

Routine cerebral angiography at the New York Neurological Institute is done in simultaneous biplane with half a second intervals between exposures The ideal stereoscopic system would enable any two successive films in either plane to be viewed stereoscopically This may be accomplished by moving the a p and lateral tubes 10 cm between exposures (using a 100 cm anode film distance and 2 to 4 cm distance from head of subject to film) A similar stereo-



Commercial model of the stereoscopic table The small box on the underside of the stretcher (at left) houses the electric motor and the microswitches for synchronization The biplane cameras are on the right

scopic effect may be accomplished by moving the subject 2 to 3 cm between exposures

A simple inexpensive apparatus was designed with this in mind The apparatus consists of an upper upholstered board on which the patient lies This in turn lies on bearings that ride on the lower board The lower board is supported on a standard hydraulic stretcher frame The patient is strapped to the upper board and an electric motor shifts the board and patient 2 to 3 cm twice per second This shift is synchronized with the roentgen tubes and the film cameras

The patient is usually not discomforted by the few seconds of twice per second alternate movements The shift of the patient rather than shift of the anode does not give a true stereo effect although it does enable one to separate overlying anatomical structures when viewed stereoscopically

An apparatus incorporating the features of this unit is now available from the Picker X ray Corporation (see the accompanying illustration)

SUMMARY

A new apparatus for serial cerebral angiography enabling simultaneous biplane stereoscopic films to be obtained

ZUSAMMENFASSUNG

Ein neuer Apparat für Serienangiographie womit simultane stereoskopische Filme in 2 Ebenen erhalten werden wird beschrieben

RESUMÉ

Description d un nouvel appareil d angiographie cérebrale en série permettant de prendre des films stéréoscopiques bidirectionnels simultanes

FROM THE NEUROSURGICAL DEPARTMENT (DIRECTOR PROF F COLUMELLA), OSPEDALE MAGGIORE, BOLOGNA, ITALY

ANGIOGRAPHY IN TRAUMATIC CEREBRAL LACERATIONS WITH SPECIAL REGARD TO SOME LESS COMMON ASPECTS

by

F COLUMELLA G B DELZANNO, G GAIST and G PIAZZA

Our concept of a traumatic cerebral laceration (5) appears not to be generally recognized and the majority of centers still consider such a condition no different from an intracerebral hematoma It may therefore be desirable that a few of the anatomic and pathologic features are considered before attention is directed to some of the angiographic characteristics

A cerebral laceration is the result of a violent impact of the brain against the surrounding parts of the skull If at the site of injury the momentum of the brain is higher than the critical point of resistance of the blood vessels and leptomeninges the latter are torn and parts of cerebral matter are crushed and become necrosed It would appear that the amount of necrotic matter may vary in size from about a centimeter in diameter and half a centimeter in depth to a massive involvement of an almost entire cerebral lobe Any bony structure projecting toward the brain and existing as such prior to the trauma may produce the injury although it is usually the lesser wing of the sphenoid against which the mass of the brain relatively free in the subdural space is thrown by the momentum The frontal lobes may also suffer severe damage by being thrust forwards and compressed in the space limited by the floor of the anterior fossa and the frontal vault at the moment of impact The occipital lobes may similarly though less frequently, be involved

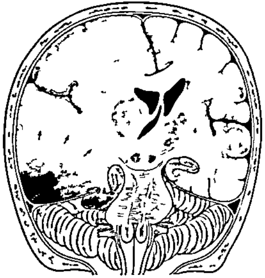


Fig 1 Schematic drawing of the lethal mechanism of a temporal laceration The necrotic area is shown in black a zone of transition lying between it and the arrows that point to the perifocal swelling Ventricular displacement and temporal herniation (secondary to the laceration) distort and compress the brain stem

Injuries produced by, for instance, a blunt object striking the skull, are of an entirely different nature The mechanism is now reversed and bone fragments from a comminuted fracture may become detached from the calvarium and penetrate the brain The margins of a simple fracture may undergo sudden and brief inward torsion and acting as two parallel blades, strike the brain almost squarely, causing damage along the surface with which they come in contact The cerebral laceration in this particular pathogenetic mechanism lies on the vault, rather than at the base, and corresponds to the fracture line The dura may be characteristically damaged and present a tear that runs *linear and parallel to the fracture line*

The chief pathogenetic element in all these injuries is the formation within the nervous substance of an area of circumscribed destruction both of the white and grey matter, always accompanied by more or less extensive damage to the leptomeninges A collection of blood, which occupies either the subdural space or the area of brain destruction or both is therefore generally formed This blood, when in contact with the crushed cerebral matter, coagulates very rapidly

On the other hand this effusion may be entirely absent, even in the presence of obvious tearing of veins and arteries This may sound paradoxical and is not easily explained The writers have however occasionally been confronted with the phenomenon and have attributed it to local vasospasm *occurring* at the time of injury

Since these hematomas are secondary to lacerations and do not always occur, they are called by us 'ematomi satelliti a term that may be translated as accessory or satellite hematomas It is evident that if the accessory



Fig 2 Probable spasm of the anterior cerebral artery in a gross right temporal laceration with a large accessory hematoma



Fig 3 Probable spasm of distal end of carotid siphon all branches of pericallosal artery and the initial portion of the Sylvian group

hematoma exceeds a certain volume it becomes a true space occupying lesion of traumatic origin

The accessory hematoma in a great number of cases is however not in itself a space-occupying lesion or a cause of internal cerebral herniation For this reason its removal may not be sufficient to save the life of the subject It is then apparent that the fundamental space occupying lesion is the mass of damaged cerebral substance This within minutes (hours at the most), is accompanied by massive localized cerebral swelling and becomes an actual 'tumour capable of grossly displacing the cerebral arteries and of causing internal herniations This edema usually subsides or decreases after the surgical removal of the necrosed area The analogy with the lethal mechanisms of a brain tumour is obvious

The writers have previously (1 2 3 4) reported on the main angiographic findings in cerebral lacerations and believe they have succeeded in demonstrating that from a pathogenetic viewpoint these lacerations are comparable with the more traditional intra cranial space occupying lesions The present communication will be devoted to certain atypical features of these conditions since the typical ones are known from the reports of other writers (6 7 10 11)

Material The total series consisted of 474 cases of acute intracranial injuries In some of the cases carotid angiography was performed more than once but these cases are considered as one unit in the tabular presentation of the findings presented below

Normal findings		254
Signs of expanding processes		
Sub or extradural hematomas	88	
Lacerations with or without accessory hematoma	117	
Intracerebral hematomas without cerebral lacerations	8	
Cases without operative or post mortem control	7	220
		Total 474

Lacerations with or without an accessory hematoma were present in 117 cases of the material and were localized as indicated below

Frontal region	14
Temporal region	66
Fronto temporal region	14
Parietal and parieto occipital region	7
Localization not specified	16
	Total 117

Discussion

Vasospasm There was angiographic evidence of arterial spasm in 10 % of the cases of traumatic intracranial expanding processes The concept of vasospasm is a logical attempt to find an explanation for the presence of a brain laceration with tearing of a relatively large vessel and no hemorrhage, or with hemorrhage quite disproportionate to the importance of the torn vessel It would then appear that the only way to demonstrate a spasm with certainty is to obtain in the same case further angiograms demonstrating normal filling of the previously spastic vessels Unfortunately this was not done in the present series of cases

Fig 2 is from a case of an extensive left temporal laceration with a subdural accessory hematoma It is probable that vasospasm was responsible for the anterior cerebral artery being visible only in its initial portion and the distal end of the carotid siphon appearing to be very thin

Appearances similar to those in Fig 2 are presented in Fig 3, there is a less marked slowing down of the circulation in the anterior cerebral and pericallosal arteries

Limitations of carotid angiography in acute cerebral injuries Cerebral angiography will not permit the definite diagnosis of cerebral laceration Similar angiographic appearances may be found in cases of intracerebral hematomas without lacerations as well as in certain cases of extracerebral hematomas This is particularly true in cases of frontal extradural hematomas and of subdural effusions limited to the frontal region or to the base of the skull The angiographic findings may thus indicate the site of the lesion but not its nature

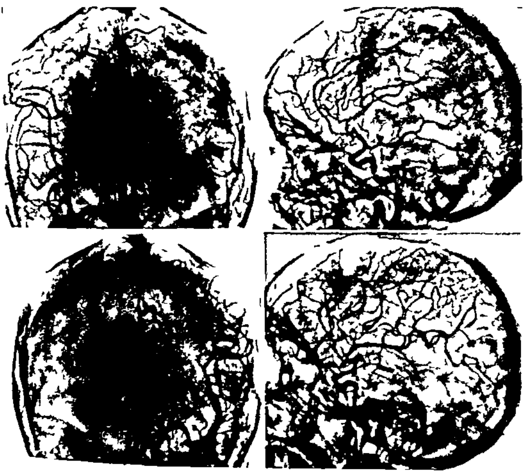


Fig 4 *Upper row* The pericallosal artery is in the midline large right temporal laceration *Lower row* Normal contralateral arteriography

Routine operation and post mortem controls have disclosed that the degree of true pathosis is usually underestimated from the angiograms This should be borne in mind when the question of surgical intervention is under consideration An ample exploratory flap centered on the angiographically indicated lesion has often proved a satisfactory procedure

Carotid angiography in cases of acute head injury is sometimes followed by marked improvement in the clinical picture which is however generally transitory Instead of regarding this as a contra indication for operation it should be taken advantage of by preparing the patient for surgical intervention Negligence to observe this has been responsible for some deaths at the beginning of the present series

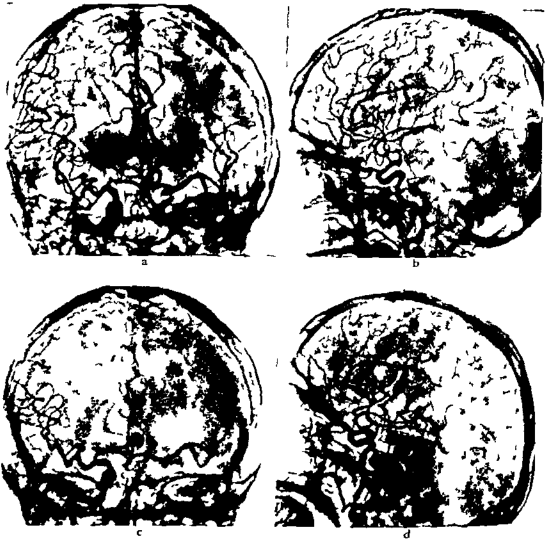


Fig 5 Left temporal traumatic expanding process with small temporo parietal accessory hematoma spontaneous recovery a) and b) Arteriography on the day of the accident c) and d) Arteriography at the end of three weeks coma

A feature that may possibly be included among the limitations of arteriography is the fact that the pericallosal artery may be seen to lie in the mid line in the a p view even in the presence of a massive cerebral laceration This is understandable in cases in which autopsy or surgery shows the presence of another laceration on the opposite side but cannot easily be explained in the case shown in Fig 4 in which the contralateral angiograms were normal

Another limiting factor in the interpretation of the films is the existence of more than one expanding lesion For example, in the case of a frontal laceration with a similar lesion in the temporal lobe the Sylvian vessels would be

displaced downwards and backwards by the frontal laceration, while the temporal lesion would displace the same structures forwards and upwards These displacements do not occur, however, when the two expanding processes balance one another so that in the lateral view the angiograms reveal no significant changes If, as it often happens these lesions are accompanied by a large subdural satellite hematoma, the a p view will only disclose dis placement of the pericallosal artery towards the opposite side and an avascular region due to the subdural effusion If then an erroneous diagnosis of extra cerebral hemorrhage is made the subsequent operation may consist of evacua tion of the hematoma without exploration of the temporal and frontal lobes and possibly also the bases of the anterior and middle fossa and massive cerebral edema may result This chain of errors even more inevitable with burr hole diagnostic procedures, is responsible for many a postoperative death in the neurosurgery of cerebral trauma It must therefore be emphasized that because of the possible co-existence of counteracting lesions the absence in the lateral view of angiographic evidence of an expanding process does not defi nitely eliminate the presence of homolateral lacerations

Other cases of this kind in which frontal and temporal lacerations are present may not always be misleading however The lateral view may be negative but the a p projection may show an upward displacement of the main stem of the middle cerebral artery so that the cerebral substance in con tact with the base of the skull is justifiably explored

The amount of space occupied by the laceration may vary considerably depending on the severity of the accompanying edema, so that the angiographic findings of lacerations may vary with the passing of time and the evolution of the lesions Edema usually increases in the first 3 to 4 days and then slowly subsides within the course of weeks Arteriography performed a few hours after the accident may therefore fail to demonstrate any lesion but a further angiographic examination, carried out a few days after the injury, may, due to the increased edema reveal the presence of perhaps a large brain laceration with or without a small accessory hematoma

The opposite phenomenon i e the spontaneous regression in size of the expanding process with improvement in the clinical picture may be more difficult to demonstrate when the first angiograms show the existence of an expanding process in a case of severe head injury operation is usually per formed or the patient dies There may however be progressive regression in a few cases (8 9) in which definite contra indications to surgery exist and the patient survives to the phase of increasing edema This is apparent in the case shown in Fig 5 in which the size of the lesion decreased with the passing of time, (a) and (b) are the angiograms on the day of the accident while (c) and (d) were obtained after three weeks The patient was a 75 year old diabetic hypertensive woman who exhibited spontaneous improvement after her injury This fact and the entity of the lesions in Fig 5a

and 5b were not considered an indication for conservative treatment but the patient's age and her poor condition were considered contra indications for operation

Conclusions

1 Cerebral angiography in acute cranial injuries may disclose severe circulatory disturbances, secondary to general or localized arterial spasm

2 Cerebral angiography in acute cerebral injuries is a valuable diagnostic procedure but does not allow a differential diagnosis between an intracerebral hematoma and a cerebral laceration This limitation is of negligible practical importance

3 The demonstration of a midline position of the pericallosal artery in the a p view does not rule out the existence of a traumatic expanding lesion even a large one, in one of the cerebral hemispheres On the other hand, it is no indication of the presence of bilateral lesions

4 Multiple, acute, traumatic expanding processes, co existing in the same case and producing counteracting vasal displacements, may result in angiographic appearances difficult to evaluate

5 The frequent co existence of multiple lesions in acute cranial injuries suggests the almost routine necessity of bilateral carotid seriography

6 Arteriography in acute cranial injuries tends to make the lesions appear smaller, or fewer in number than they actually are Surgery is therefore nearly always indicated in doubtful or mild cases

SUMMARY

Cerebral angiography in acute head injuries some of the limitations of which are discussed may disclose evidence of marked vascular spasm The concept of traumatic cerebral laceration is advanced and considered in detail

ZUSAMMENFASSUNG

Die cerebrale Angiographie bei akuten Hirnverletzungen hat ihre Begrenzungen die besprochen werden sie kann aber ausgesprochene Gefässspasmen aufzeigen Der Begriff traumatische cerebrale Laceration wird aufgestellt und im einzelnen besprochen

RÉSUMÉ

L angiographie cérébrale au stade aigu des traumatismes craniens dont les auteurs discutent certaines des limites d indications peut déceler des signes de spasme vasculaire marqué Les auteurs proposent le concept de lacération cérébrale traumatique et l étudient de façon détaillée

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CLINIQUE NEUROCHIRURGICALE DE LA PITIÉ ET CENTRE NEUROCHIRURGICAL DES HÔPITAUX PSYCHIATRIQUES DE LA SEINE (PROF M DAVID), PARIS, FRANCE

SÉMIOLOGIE ANGIOGRAPHIQUE DE L'ARTÈRE CÉRÉBRALE ANTÉRIEURE

par

D DILENGE et J P CONSTANS

Les limites entre les variations normales et pathologiques de l'artère cérébrale antérieure s'avèrent parfois très difficiles à définir et dans quelques cas leur évaluation inexacte peut conduire à des erreurs de diagnostic assez graves Néanmoins, ce sujet ne semble avoir suscité que peu de travaux dans la littérature angiographique, aussi nous a-t-il paru qu'il méritait d'être mieux connu, notamment grâce aux documents obtenus par l'emploi de la sériographie rapide De l'expérience d'environ 3 000 examens dont 1 000 pratiqués avec des sériographies rapides, il est maintenant possible de dégager certaines données que nous pensons intéressant de rapporter

Un premier point concerne la dissemblance des variations des deux troncs artériels situés en amont et en aval de l'artère communicante antérieure, de telles variations pouvant exister indépendamment aussi bien pour l'un que pour l'autre La définition de LINDGREN qui répond à des données d'ordre topographique se montre extrêmement satisfaisante puisqu'elle permet de distinguer clairement l'artère cérébrale antérieure de l'artère péricalleuse celle-ci représentant le tronc compris entre l'artère communicante antérieure et le splénium du corps calleux Cette distinction est d'autant plus importante que les conditions d'opacification sont fréquemment différentes pour l'un et pour l'autre des deux segments

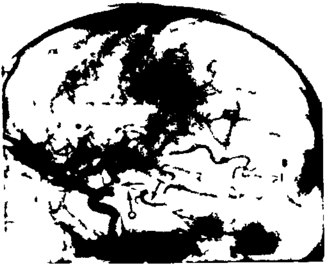


Fig 1 Le calibre de l artere cérébrale antérieure (↓) ainsi que celui de l artere communicante postérieure (↓) est dans ce cas peu developpe l artère péricalleuse (+) et l artere cérebrale postérieure (↓) sont néanmoins bien injectées et apparaissent de calibre normal



a b

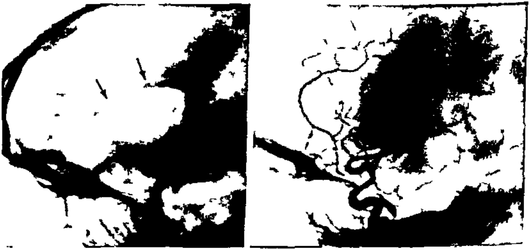
Fig 2 a) L artere pericalleuse est particulierement sinueuse t depasse de 0 8 cm la lign médiane b) Le septum pellucidum se trouve par contre strictement sur la l gne médiane

Les variations normales de l artere cerebrale antérieure sont peu importantes Elles concernent essentiellement le calibre et plus rarement le trajet de l artere

Dans nos cas normaux le calibre se trouve tres frequemment inferieur a celui de l artere cérebrale moyenne (79 %) alors qu il est egal dans 18 % et



Fig 3 La surface du corps calleux est ici indiquee par la présence d une faible quantite de contraste (↓↓) il est ainsi possible d apprécier la distance entre le corps calleux et l artere peri calleuse



a b

Fig 4 a) La pneumographie a bien mis en evidence la citerne pericalleuse (↓↓) b) Il est d ficile d affirmer s il s agit de l artère pericalleuse ou de l artere calloso-marginale

superieur dans 3 °₀ seulement Dans 2 °₀ il est extremement reduit parfois au point que l artere pericalleuse ne s injecte pas Cependant un calibre extre mement fin n est pas toujours un obstacle a l opacification de l artere peri calleuse en effet dans quelques cas l artere pericalleuse s injecte normalement et apparait de calibre habituel Dans un cas, notamment, le calibre de l artere cerebrale anterieure etait tres mince ainsi que celui de l artere communicante



a b

Fig. 5. a) L'opacification de l'artère péricalleuse est très fugace. b) Sur le 2ème cliché de la série lorsque la carotide interne est encore injectée, elle a en effet disparu.

postérieure, malgré cela l'opacification de l'artère péricalleuse et des deux artères cérébrales postérieures était normale de même que leur calibre.

D'autres fois, l'artère cérébrale antérieure peut ne pas apparaître sur l'angiogramme, mais l'artère péricalleuse qui est dans son prolongement s'opacifie par l'artériographie controlatérale.

En ce qui concerne le trajet, l'artère peut former des boucles assez accusées. Parfois ces boucles peuvent simuler l'image d'un anévrisme sacculaire, en particulier lorsqu'elles se trouvent à proximité de l'artère communicante antérieure, et dans quelques cas il peut être difficile de les différencier d'un véritable anévrysme, surtout s'il s'agit d'un syndrome d'hémorragie méningée. Il faut alors pratiquer plusieurs projections de 3/4 avec une inclinaison différente du rayon central pour pouvoir obtenir une certitude, car la boucle à ce niveau peut être très complexe.

Les variations normales de l'artère péricalleuse, visibles sur un angiogramme sont par contre plus importantes. Elles tiennent principalement à ses rapports avec la ligne médiane ou avec la surface du corps calleux et à son mode d'opacification. Comme LINDGREN, TONNIS et SCHIEFFER l'ont souligné, l'artère péricalleuse peut dessiner des sinuosités qui d'un côté et de l'autre débordent la ligne médiane. Dans nos cas normaux elle se trouve la dépasser 15 fois sur cent, mais le déplacement qui en résulte n'excède pas 0,8 cm. Dans la plupart de ces cas un examen pneumographique a été pratiqué ultérieurement, cet examen a permis de constater la position tout à fait médiane du septum pellucidum. Onze fois sur cent, ces sinuosités intéressaient le segment basal de l'artère, 3 fois le segment basal et antérieur, une seule fois le segment basal

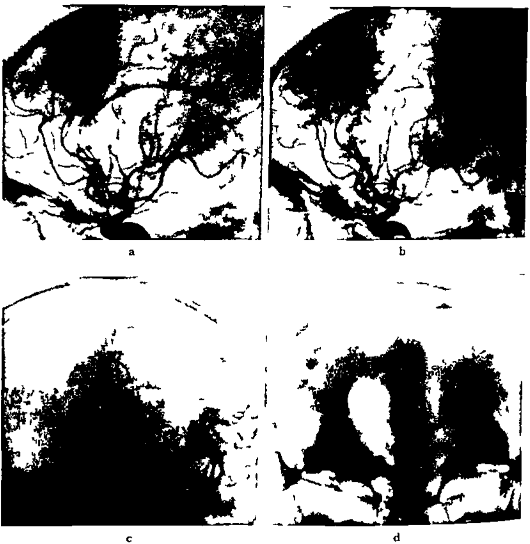


Fig 6 Ici aussi l opacification de l artere pericalleuse est particulierement fugace (a) puisque deja sur le 2eme cliché de la serie de profil (b) aucune trace ne subsiste L angiogramme de face (c) ne montre aucun deplacement artériel par rapport à la ligne mediane mais comme le 2ème cliché de la serie de profil il n objective pas l artere péricalleuse Le septum pellucidum se trouve [illegible] deplace sur le pneumogramme (d)

anterieur et superieur Presque toujours nous avons noté que l artere dessinait des sinuosites nettement marquees egalement sur l angiogramme de profil Nous croyons que cette correlation entre les clichés de face et de profil représente un critere utile en faveur des variations normales de l artere péricalleuse par rapport a la ligne médiane Dans quelques cas la sinuosité, se dessinant plutot du cote de l injection, a masque le déplacement réel de l artère vers le coté opposé, l artere paraissait alors se projeter sur la ligne médiane Le



Fig 7 Les deux arteres péricalleuses forment un trone unique jusqu au genou du corps calleux (↓) Ici on retrouve les segments supérieurs des deux artères péricalleuses (↓↓) et les artères calloso-marginales des deux cotes (↓↓)

septum pellucidum, mis en évidence par la pneumographie, se trouvait par contre déplace

En ce qui concerne les rapports avec le corps calleux nous avons parfois note, ici aussi en tenant compte des controles pneumographiques, que l artere pericalleuse peut suivre un trajet a distance de la surface du corps calleux dont elle se trouve eloignee de 0 5 a 1 5 cm sur les angiogrammes de profil L artere semble alors se derouler suivant un arc qui apparait plus grand que d habitude Dans quelques uns de nos cas on pouvait discerner une faible quantité de contraste au niveau de la surface du corps calleux rendant ainsi possible l appreciation de ses rapports avec l artere pericalleuse D autres fois il etait extremement difficile de savoir s il s agissait d une variation pathologique ou normale C est dans de tels cas que l absence fréquente de l opacification du segment superieur de l artere joue egalement un role, mais bien souvent il s agit d une position anormale de l artere par rapport a l artere calloso-marginale il est alors bien difficile de distinguer s il s agit de l une ou de l autre

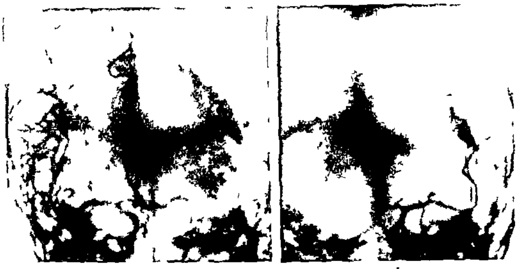
L opacification de l artere pericalleuse comme on le sait peut etre en rapport avec certaines variations anatomiques, mais aussi avec certaines conditions hemodynamiques a un moment donne dont nous ne connaissons pas encore tout le mecanisme Il nous a ainsi ete donne de constater dans quelques cas comme l a fait Lewin une opacification tres fugace de l artere pericalleuse au point que son image avait deja disparu alors que le produit de contraste se trouvait encore dans le siphon Ce fait aussi peut conduire a des erreurs d interprétation dans le cas ou il existe une artere calloso marginale susceptible de simuler l artere pericalleuse et ou celle ci ne s est pas trouvee opacifiee sur



Fig. 8. L'artère péricalleuse dans ce cas est unique pour les deux hémisphères; ses branches secondaires sont plus nombreuses et réparties aux deux côtés.

la série de face. L'artère péricalleuse peut alors être déplacée par l'existence d'une lésion expansive et l'artère calloso marginale rester sur la ligne médiane. On risque donc en l'absence d'une opacification de l'artère péricalleuse et en présence d'une artère calloso marginale capable de la simuler de commettre des erreurs de diagnostic importantes. Dans un cas que nous avons observé récemment, on notait sur la ligne médiane une artère qui paraissait bien être l'artère péricalleuse et cela semblait confirmé par le premier cliché de la série de profil où l'on pouvait constater l'opacification de l'artère péricalleuse. La disparition rapide de l'artère dès le deuxième cliché de la série alors que le contraste se trouvait encore au niveau du siphon, nous avait pourtant frappé et une pneumographie renforça notre doute puisque le septum pellucidum était fortement déplacé de la ligne médiane et qu'il ne pouvait donc s'agir sur l'angiogramme de face que de l'artère calloso marginale.

De l'étude enfin des angiographies bilatérales est ressortie la multiplicité des modes d'injection de l'artère péricalleuse. A ce propos nous désirons attirer l'attention sur les cas où l'artère semble être unique pour les deux côtés. Cette éventualité est assez rare et dans certaines statistiques (TÖNNIS et SCHIEFFER) elle n'atteint même pas 1 %. Parfois elle peut dépendre d'une opacification qui ne se vérifie pas à un moment donné, mais parfois d'une vraie anomalie anatomique qui fait qu'il existe une seule artère péricalleuse. Dans un



a b

Fig 9 Image typique de thrombose de l artère péricalleuse l opacification de l artere pericalleuse du cote gauche fait défaut (a) L artere péricalleuse du coté oppose s injecte simultanement aux arteres cerebrales antérieures des deux cotés mais l injection des branches secondaires est seulement homolaterale (b)

de nos cas nous avons pu constater egalement la presence d un tronc unique jusqu'au genou du corps calleux ou se situait l origine de deux segments superieurs de l artere pericalleuse et de deux arteres calloso marginales

Dans les cas ou l injection d une artere pericalleuse d un cote fut defaut et ne se produit pas par l injection de l autre cote nous avons observe que ce fait est certainement en relation avec une anomalie anatomique lorsque de l artere pericalleuse controlaterale visualisee sont issues toutes les branches secondaires des deux cotes Ceci peut etre confirme aussi par l injection bilaterale *simultanee des arteres cerebrales anterieures Dans les autres cas* il peut s agir d un mode particulier d opacification a un moment donne Mais il faut aussi tenir compte du fait que l injection bilaterale des branches secon daires peut etre simulée par l opacification bilaterale des branches para cen trales, *pre cuneennes* et *parieto occipitales internes opacification qui* se vérifie frequemment tant d un cote que de l autre (nous l avons trouvee dans 25 % de nos cas) Il s ensuit que le diagnostic de thrombose de l artere peri calleuse qui suivant notre experience est tres rare se trouve donc rendu tres difficile Nous pensons qu il peut etre affirme *dans les cas ou l opacification de* l artere péricalleuse fait defaut d un cote et se produit de l autre simultane ment a celle des deux arteres cerebrales anterieures l injection des branches secondaires étant seulement homolaterale

RÉSUMÉ

Il est important de fixer des limites anatomiques precises au segment artériel qui constitue l artere cerébrale anterieure La définition de LINDGREN qui répond a des données d ordre topographique traduit la dissemblance des variations dans les deux tronçons artériels situés en amont et en aval de la communicante antérieure La portion comprise entre le siphon et la communicante anterieure (A cérebrale anterieure) n est soumise qu a des variations relativement moderees du calibre de l artere Par contre l aspect du segment situé au-dela de la communicante (A pericalleuse) peut poser certains problemes diagnostiques en raison des variations angiographiques importantes dont il est l objet

SUMMARY

It is important that definite anatomic boundaries of the segment supplied by the anterior cerebral artery should be defined LINDGREN s definition based upon topographic data, indicates the dissimilarity of the variations that occur in the two arterial segments above and below the anterior communicating artery The region between the siphon and the anterior communicating artery (anterior cerebral artery) is subjected to only relatively moderate changes in caliber The appearances of the segment beyond the communicating artery (pericallosal artery) on account of the important angiographic variations that may occur may however give rise to certain diagnostic difficulties

ZUSAMMENFASSUNG

Es ist wichtig dass die anatomischen Grenzen des durch die Art. cerebr ant versorgten Gebietes endgultig festgelegt werden Die Definition LINDGREN s die sich auf topographische Angaben bezieht zeigt die Vielfalt der Variationen die in den zwei arteriellen Segmenten, ober und unterhalb der Art communic ant auftreten Die Strecke zwischen dem Siphon und der Art communic ant (A cerebr ant.) ist nur rel geringen Veranderungen die sich auf das Kaliber der Arterie beziehen unterworfen Das Aussehen des Segmentes oberhalb der Art communic ant (i e der Art pericallosa) mag jedoch im Hinblick auf die wichtigen angiographischen Variationen die vorkommen konnen zu gewissen diagnostischen Schwierigkeiten Anlass geben

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DISTRIBUTION OF SPASM IN THE INTRACRANIAL ARTERIES AFTER SUBARACHNOID HAEMORRHAGE

by

GEORGE DU BOULAY

The occurrence of temporary narrowing of intracranial arteries after subarachnoid haemorrhage is now well documented. It is usually known as spasm. Spasm may also be demonstrated in the carotid artery in the neck. (See POPPEN 1951, ECKER & RIEMENSCHNEIDER 1951, NORLEN & OLIVECRONA 1953, POOL, JACOBSEN & FLETCHER 1958, FLETCHER, TAVERAS & POOL 1959 and also MONIZ 1942 and ECKER 1945.)

Some important aspects of spasm of intracranial arteries are as follows:

1. Severe spasm may predispose to cerebral infarction and therefore make surgery for intracranial aneurysms very dangerous (LOGUE 1956).

2. It has been suggested that angiography itself may cause or increase the spasm.

3. Spasm may occasionally make the demonstration of an aneurysm difficult when the contrast filling of the appropriate part of the circle of Willis is poor.

4. Many believe that the situation of a recently ruptured aneurysm may be indicated by the presence of spasm of arteries leading to it (POOL, JACOBSEN & FLETCHER).

For these reasons the distribution of spasm in the circle of Willis and its branches, in cases where the site of the bleeding aneurysm is known, is of interest In addition, the time relationship of contraction and relaxation to bleeding angiography and surgery have more than academic importance

Recognition of spasm Some congenital inequality of calibre in the intracranial arteries of the two sides is relatively common but causes real difficulty in the diagnosis of spasm in carotid angiography in only one situation, i e in the first parts of the anterior cerebral arteries where the congenital inequality may be extreme

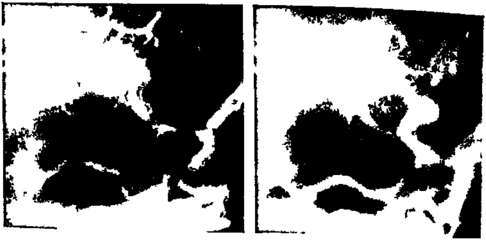
Spasm often produces a smooth contraction of a considerable length of one or more of the main arterial trunks This contraction is likely to start at one point of branching and continue to another bifurcation, possibly past several intervening divisions Atherosclerosis, on the other hand, commonly causes multiple, irregular short areas of narrowing with loss of parallelism of arterial walls and not uncommonly, very wide segments as well as stenosed areas (BULL et coll 1960)

It is sometimes permissible, therefore, when the features are marked, to diagnose athero-sclerosis or spasm on a single angiographic examination. When, however, only a short length of artery is affected, it is less easy and may be impossible, as in the carotid siphon, for example, where localised spasm may often be seen as a fusiform narrowing usually stopping before it reaches the termination of the artery In otherwise doubtful cases, if angiography is repeated after a few days or weeks, alteration in the calibre of the vessels shows that the narrowing was the result of muscular contraction

Occurrence Spasm is seen commonly after subarachnoid haemorrhage, before and sometimes after operation, and rarely at angiography performed for the investigation of cerebral tumour It has even been suggested that angiography itself may play some part in its production Its exact cause, mechanism and method of propagation are not discussed here

Material The 137 cases in this series all had intracranial aneurysms, and presented with subarachnoid haemorrhage Excluding those in which angiography had been performed after carotid ligation and which showed diminution of the calibre of cerebral vessels on the side on which ligation had been done, there were 52 cases which at repeated angiography were found to have arteries which altered in calibre Of these fifty two cases 44 also had post-operative angiographic examinations Another 32 of the 137 cases showed good evidence of spasm on a single angiogram obtained within 14 days of the subarachnoid haemorrhage, and in 53 cases no evidence of spasm was seen

The technique and apparatus were in all cases the same The alteration in calibre shown on successive angiograms has only been accepted as real when it was of a degree to be beyond dispute



a b

Fig 1 a) Right carotid arteriography 18 days after subarachnoid haemorrha aneurysm the carotid siphon is narrow (middle and anterior cerebral arter b) Right carotid arteriography 14 days after (a) Carotid and posterior c wider (middle and anterior cerebral arteries were also dilated) The aneurysm

Spatial relationship of spasm to aneurysm

A *Anterior communication aneurysm* Narrowing of one cerebral artery and often of the carotid artery on the oppo an almost constant finding after subarachnoid haemorrhage f in this situation

B *Aneurysms in other situations* Spasm is somewhat comm side as the aneurysm but may be seen in distant arteries as of artery of normal calibre between those in spasm (Fig 1) by segments not necessarily contiguous segments in turn and bution of spasm demonstrated at angiography must depend up it is performed

Death occurred in nearly half of the cases which were dia spasm on a single angiogram seven of them before any atter made (i e within the first 48 hours after subarachnoid haem seven are a striking group in whom the haemorrhage was foll severe cerebral irritation and the patient, being desperat examined by angiography as an emergency In many cases degree of spasm was very considerable — sometimes almost of both carotids were affected

C *Multiple aneurysms* There were nine cases fulfilling the following conditions

1 More than one aneurysm was present

2 It was known which one had been responsible for the haemorrhage because of the appearance at operation or post mortem

3 Arterial narrowing, which was proved by subsequent examination to have been due to spasm, was observed

In six of these cases, spasm was shown in direct relation to the bleeding aneurysm (i e spasm either in the artery from which the aneurysm arose, or in the case of anterior communicating aneurysms, spasm in the first part of one or other anterior cerebral artery) On the other hand, in two of these six cases spasm was also present in the artery from which a second aneurysm arose which had not been responsible for the recent subarachnoid haemorrhage, and in a third case there was no spasm in relation to the middle cerebral aneurysm which had bled, but there was spasm in the carotid siphon of the same side in relation to a posterior communicating aneurysm which was not responsible for the haemorrhage

Most cases also showed some vessel spasm not directly related to any of the aneurysms though all except one of these distant contracted vessels were on the same side as the bleeding aneurysm

Chronologic relationship of spasm to its cause

It is necessary to try to separate the several factors which may be responsible

A *Angiography*

No alteration of calibre of an intracranial artery has been observed during a single examination although repeated injections are sometimes necessary (Occasionally however, a slight diminution in size of the carotid artery in the neck may be seen)

Relaxation of arteries at a second examination has been observed after comparatively short times (Table 1) suggesting that the effect if any of angiography did not last long after the first angiogram and was absent on the second occasion

At re examinations (undertaken to provide further information before operation) when no second haemorrhage had occurred, there was never an increase in spasm in any already contracted artery nor did any previously wide artery appear to have become narrow

It therefore seems unlikely that angiography plays any part in the production of spasm of intracranial arteries

Table 1

Intervals after angiography at which relaxation of arteries was observed on a second angiogram (no intervening incident)

Number of cases	Days
1	2
1	4
3	5
1	6
2	8
1	14
1	27

Table 2

Intervals between subarachnoid haemorrhage and demonstration of relaxation of previously narrow arteries (two or more angiograms no operation)

Number of cases	Relaxation between
1	4—8 days
1	11—13 »
1	9—16 »
1	15—21 »
1	19—24 »
1	21—26 »
1	18—32 »

after subarachnoid haemorrhage

Table 3

Longest intervals for which spasm is known to have persisted in arteries which subsequently relaxed

Previous event	Interval
Operation	1 month
	1 »
	1 »
	2 months (after carotid ligation)
	21 months (after exposure of common carotid artery)
Subarachnoid haemorrhage	1 month
	3 months (widening of arteries on both sides finally observed 14 days after operation)

B *Subarachnoid haemorrhage*

1 *Contraction of arteries* Some evidence of spasm was found on carotid angiography in about two-thirds of cases after subarachnoid haemorrhage and when present was always demonstrated in the earliest angiograms Within a few hours of the haemorrhage spasm may be very severe and widespread

2 *Relaxation of arteries* Table 2 shows the period in days after subarachnoid haemorrhage during which relaxation was seen In seven cases which were re-examined although no operation and no fresh subarachnoid haemorrhage had taken place some relaxation of arteries was shown in the final angiograms (Fig 2) In two of these the final angiograms still showed one narrow artery but in the others the calibre of the vessels appeared to be within normal limits

These figures suggest that relaxation of spasm after subarachnoid haemorrhage takes from one to four weeks and is often complete in the third week The longest periods for which spasm of one or more arteries is known to have persisted subsequently to relax (as demonstrated by three or more angiograms) are shown in Table 3 which refers only to cases in which the most persistent arterial narrowing occurred

3 *Contraction of arteries after fresh subarachnoid haemorrhage* There were five cases which after the first angiography and while under observation in hospital suffered a second haemorrhage and in which further angiographic studies demonstrated vascular spasm In one case there was persistence of spasm (which subsequently relaxed) from the previous haemorrhage The other four



a b



c

Fig 2 a) and b) Left carotid arteriography Left supraclinoid aneurysm carotid siphon definitely narrow subarachnoid haemorrhage had occurred two months ago and again two days ago c) Left carotid arteriography seven days after (a b) The carotid siphon and middle cerebral artery are wider The aneurysm has changed in size by spontaneous obliteration of a loculus

cases all had fresh spasm the angiography being performed one to four days after the second haemorrhage

C *Operation*

The 44 cases considered had broadly speaking one of two kinds of operation — either direct attack on the aneurysm itself or clipping of its main artery of supply without exploration In 24 cases some arterial relaxation at post operative examination was found (Table 4)

There is insufficient evidence of how soon after operation relaxation usually takes place but it can be seen that in the majority some relaxation may be demonstrated before the end of the third post operative week Occasionally it has been shown that spasm may persist for as long as one month after operation

Table 4

Intervals after operation when relaxation of arteries was observed

No of cases	Days
1	5
2	11
2	12
1	13
5	14
3	15
1	16
1	17
2	18
1	19
1	23
1	24
1	27
1	33
1	34

Table 5

First demonstration of relaxation of arteries after subarachnoid haemorrhage when an operation had been performed in the interval

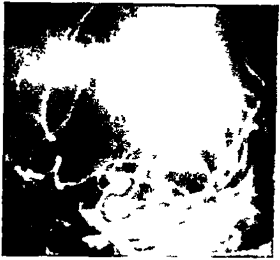
Relaxation occurred between these days after subarachnoid haemorrhage		Operation performed on this day after subarachnoid haemorrhage
First angiography	Second angiography	
0	15	5
1	16	5
7	16	4
1	17	6
1	18	4
1	20	8
3	21	6
1	22	6
4	24	5
3	29	5
10	30	12
0	35	2
16	35	17
19	37	24
4	38	6
19	39	24
9	44	17
43	65	51
39	74	62
8	2 years	12

but this is usually in cases in which operations have followed very closely upon the subarachnoid haemorrhage (Tables 3 and 5) There is at least no direct evidence that generalised spasm in these cases has been much prolonged by operation

1 *Aneurysms other than in the region of the anterior communicating artery* In Table 6 are recorded the times after which spasm was first shown to have diminished following direct attack upon aneurysms in different sitations

In the majority of all post operative angiographies the artery most intimately connected with the aneurysm and the artery most handled at operation relax as soon as any of the other arteries In four of these nine cases however, there was some persistent narrowing of vessels in the immediate vicinity of the aneurysm in the final angiogram though there is no evidence that operation tends to prolong spasm in arteries at any distance from the aneurysm (Table 5)

2 *Aneurysms in the region of the anterior communicating artery (anterior cerebral artery clipped)* The first parts of the two anterior cerebral arteries are often



a



b



c

Fig 2 (a) and (b) Left carotid arteriographs Left supraclinoid aneurysm carotid siphon definitely narrow subarachnoid haemorrhage had occurred two months ago and again two days ago (c) Left carotid arteriograph seven days after (a, b) The carotid siphon and middle cerebral artery are wider The aneurysm has changed in size by spontaneous obliteration of a loculus

cases all had fresh spasm, the angiography being performed one to four days after the second haemorrhage

C *Operation*

The 44 cases considered had broadly speaking one of two kinds of operation — either direct attack on the aneurysm itself or clipping of its main artery of supply without exploration In 24 cases some arterial relaxation at post operative examination was found (Table 4)

There is insufficient evidence of how soon after operation relaxation usually takes place but it can be seen that in the majority some relaxation may be demonstrated before the end of the third post-operative week Occasionally it has been shown that spasm may persist for as long as one month after operation

artery widening is recorded in Table 7 in the eight cases of this category In two cases the difference in diameter of the two anterior cerebral arteries had disappeared before operation, and in two other cases both anterior cerebral arteries appeared narrow

Conclusions

Spasm of the intracranial arteries is seen in about two thirds of all cases of subarachnoid haemorrhage examined during the first few days by carotid an giography At first in severely ill patients it may be very widespread Re laxation may take from a few days to a month In most patients a great deal of relaxation will have occurred within three weeks Spastic segments of artery tend to begin and end at vessel junctions so these points of alteration in calibre serve no function in localising aneurysms which may be difficult to see

There is no evidence that operation commonly provokes or prolongs general ised spasm Persistent narrowing in the immediate vicinity of an aneurysm may be found after direct attack upon it Angiography has little effect upon the spasm

Distribution of the spasm gives only the most nebulous clue to the position of a bleeding aneurysm, except in the cases with anterior communicating artery aneurysms where a little further help may be obtained

Acknowledgement

All the patients referred to in this paper were under the care of Mr V Logue I am grateful for his permission to use this material and for the stimulus of discussion Many of the arterio graphies were performed by Dr David Sutton and some by our senior registrars at various times to whom I am also very much indebted

SUMMARY

The angiograms many of them repeated of 137 cases of intracranial aneurysms have been analysed in order to discover the time relationship of spasm of arteries to bleeding angio graphy and operation and the distribution of spasm in relation to the position of the aneurysm

ZUSAMMENFASSUNG

Die (vielfach wiederholten) Angiogramme von 137 Fallen von intrakraniellen Aneurysmen wurden analysiert um das zeitliche Verhaltnis zwischen Spasmus und art Blutung Angio-graphie und Operation sowie die Verteilung des Spasmus im Hinblick auf die Lokalisation des Aneurysma klarzulegen

RÉSUMÉ

Les angiographies (dont beaucoup ont été répétées) de 137 cas porteur d anévrismes intra craniens ont été étudiées pour découvrir les rapports dans le temps entre le spasme artériel et l hemorragie l angiographie et l opération et entre le siege du spasme et celui de l ané vrisme

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L'ARTERE CEREBELLEUSE SUPERIEURE DANS LES TUMEURS DE LA FOSSE POSTERIEURE

par

D ECONOMOS et A PROSALENTIS

En parcourant les travaux sur l arteriographie vertébrale dans les tumeurs de la fosse postérieure, on se rend compte que ceux ci sont surtout descriptifs faisant essentiellement etat des deformations observées dans chaque cas

Jusqu a present l accent avait ete mis d une part sur les deplacements de l artere cerebelleuse inferieure et de ses branches, d autre part sur les defor mations en masse de l artere basilaire et de ses branches

Nous etant attaches a l etude corrélative des signes arteriographiques dans les tumeurs de la fosse posterieure en rapport avec les donnees pneumographi ques iodoventriculographiques et operatoires il nous est apparu que l artere cérebelleuse superieure meritait bien la qualification d artere cle dans le diag nostic topographique des tumeurs sous tentorielles

Classification des tumeurs de la fosse postérieure

En tenant compte d une part de la topographie de l arbre arteriel de la fosse posterieure, d autre part de la necessite pratique du point de vue operatoire de la distinction entre tumeurs de la ligne mediane et tumeurs laterales nous avons éte amenes á adopter la classification suivante pour la grande majorité des tumeurs sous tentorielles

I *Tumeurs medianes* On peut distinguer d avant en arriere tumeurs du clivus tumeurs intraprotuberantielles tumeurs du 4eme ventricule tumeurs vermiennes



Fig 1 Morphologie habituelle des artères cerébelleuses supérieures a) Artère du type court b) Normale c) Artere du type sinueux On distingue les trois portions décrites dans le texte portion A prépontique angle B portion C latéropontique



Fig 2 Tumeurs du clivus a) Tumeur du clivus strictement médian absence de déplacement latéral de l artère basilaire et d asymétrie apparente de ses branches b) Tumeur du clivus latéralisée à gauche avec refoulement de l artère basilaire vers le côté opposé allongement apparent de l artère cérébelleuse superieure et de l artere cérébrale postérieure gauche (→) par rapport à celle du coté opposé c) Refoulement en arrière du tronc basilaire et de la portion intracranienne de la vertébrale par la tumeur qui les sépare du clivus



Fig 3 Tumeur du clivus latéralisé à droite

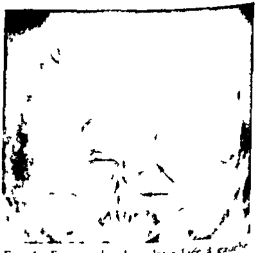


Fig 4 Tumeur du clivus latéralisée à gauche (Même cas représenté en fig 2b)



Fig. 5. Tumeur du clivus de profil (Même cas illustré sur fig. 2c.)

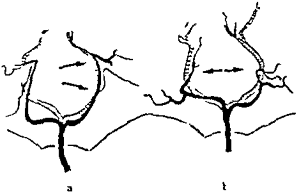


Fig. 6. Tumeurs intraprotubérantielles. a) Tumeur à développement unilatéral prédominant gauche avec soufflure de la courbe circumpontique des artères cérébelleuse supérieure et cérébrale postérieure (→) gauches. b) Tumeur du pont à développement symétrique sans déformation nette de ces artères.

et paravermiennes, tumeurs extraparenchymateuses postérieures de la ligne médiane (supérieures naissant de la tente, inférieures situées en regard de l'écaille de l'occipital).

II. *Tumeurs latérales* : tumeurs intracérébelleuses (tumeurs hémisphériques), tumeurs extracérébelleuses (basales : tumeurs de l'angle, du trou déchiré postérieur ; supérieures : naissant de la tente, postérieures : tumeurs de la convexité du cervelet).

III. *Tumeurs du trou occipital* qui s'apparentent, du point de vue chirurgical, aux tumeurs cervicales hautes.

IV. *Tumeurs du foramen ovale de Pacchioni* (incisura tentorii) qui forment un groupe à part et se développent à cheval sur la région épiphysaire et la région sous-tentorielle.

Ces deux derniers groupes réalisent des localisations de frontière et ne seront pas traités dans notre exposé qui concerne uniquement les tumeurs pures de la fosse postérieure.

Anatomie neuroradiologique de l'artère cérébelleuse supérieure

Du point de vue neuroradiologique on peut distinguer trois portions à l'artère cérébelleuse supérieure : le segment initial prépontique A se dirigeant de dedans en dehors ; l'angle B que l'artère fait en contournant la protubérance ; le segment latéropontique C terminal qui schématiquement se divise



Fig 7 Tumeur intraprotuberantielle latéralisée à droite Le schema 6a est le calque *inversé de cette figure*



Fig 8 Tumeur du pont à développement bilatéral

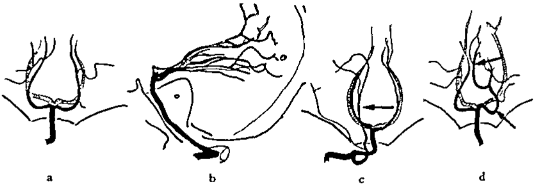


Fig 9 Tumeurs medianes et paramedianes postérieures a) Tumeur du 4eme ventricule Aspect *légerement etiré des arteres cérébelleuses supérieures b) Tumeur du vermis Artere basilaire* refoulee en avant contre le clivus etirement des arteres cérebelleuse superieure et cerebrale posterieure c) Tumeur médiane et paramédiane gauche du vermis inferieur Aspect étiré des artères cerebelleuse superieure et cerebrale posterieure branche interne (→) de l artere cérébelleuse inferieure gauche refoulee vers le coté opposé d) Tumeur mediane et paramediane du vermis supérieur gauche La branche interne de l artere cérebelleuse superieure gauche (→) est refoulee ver la droite le tronc de l artere est replie sur lui même avec fermeture de l angle B (→)

en 1—2 branches medianes a distribution vermienne et paravermienne et des branches intermédiaire et laterale a distribution hemispherique longeant la face superieure de l hemisphere cerebelleux (Fig 1)

Sur Fig 1 on a schematiquement represente les trois portions de l artere Cette meme figure illustre par ailleurs deux types morphologiques usuels (le type arrondi ou court et le type sinueux ou long) de l aspect arteriographique de cette artere



Fig 10 Tumeur du 4ème ventricule



Fig 11 Tumeur du vermis

La distinction de ces differents segments est nécessaire car les deformations observées portent de preference sur tel ou tel segment, caractere dont elles tirent leur valeur localisatrice

Donnees arteriographiques dans les differentes localisations de tumeurs sous-tentorielles

I *Tumeurs médianes*

Tumeurs du clivus Les deformations observées sont trop connues pour qu'on ait besoin d'y insister Sur les cliches de profil on trouve un refoulement en arriere de la basilaire, pathognomonique de cette localisation Sur les cliches de face il n existe pas de deformation apparente de la basilaire et de ses branches, si la tumeur se developpe derriere le clivus symetriquement par rapport a la ligne mediane

Par contre la tumeur a développement asymetrique allonge et souleve le segment A de l artere cerébelleuse superieure d un cote ou encore le segment initial de la cerebrale posterieure correspondante plus tard elle refoulera vers le coté opposé le tronc basilaire et meme la vertebrale, si la tumeur descend suffisamment bas (Figs 2 3 4 et 5)

Il est vrai que l encephalographie gazeuse pourrait demontrer l existence de petites tumeurs du clivus non visibles sur les arteriogrammes Mais quand ces tumeurs a developpment lent s accompagnent de signes cliniques leur volume est dejà tel qu elles ne restent pas meconnues par l arteriographie

Tumeurs intraprotuberantielles Quand elles soufflent suffisamment la protuberance elles peuvent se signaler sur les clichés de face par un elargissement de la courbe que fait l artere cerébelleuse supérieure autour de la protuberance



Fig. 12. Tumeur médiane et paramédiane du vermis inférieur.



Fig. 13. Tumeur médiane et paramédiane du vermis supérieur. Même cas que sur fig. 9d.

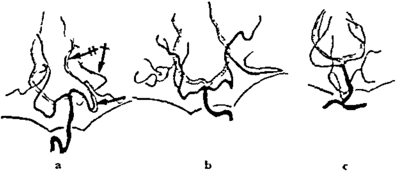


Fig. 14. Tumeurs latérales intracérébelleuses. a) Métastase gauche haute. L'artère cérébelleuse supérieure (double) gauche est repliée sur elle-même. L'angle B apparaît plus aigu (→). Les branches internes (→→) refoulées vers la droite, ses branches intermédiaire et latérale (++) abaissées. b) Gliome hémisphérique haut gauche. Fermeture de l'angle L. Les branches interne, intermédiaire et latérale de l'artère cérébelleuse supérieure forment une fourche circonscrivant la tumeur. c) Gliome hémisphérique bas gauche. L'artère cérébelleuse supérieure homolatérale n'est pas déformée. La branche interne de la cérébelleuse inférieure gauche est refoulée vers la droite, sa branche externe forme une fourche circonscrivant la tumeur.

Cet élargissement est tantôt unilatéral et alors facilement reconnaissable, ou bien bilatéral mais alors difficile à distinguer avec certitude d'une variation de forme non pathologique. Figs 6, 7 et 8.

Dans cette localisation les clichés de profil n'apportent aucun élément diagnostique. Aussi la visualisation de l'aqueduc par moyens de contraste positif ou négatif ainsi que celle de la citerne prépontique restent encore les procédés de choix.

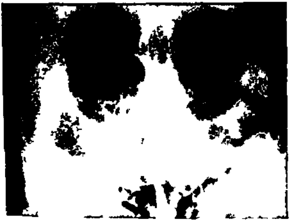


Fig 15 Métastase intracerebelleuse haute Le schéma 14a est le calque inversé de cette figure



Fig 16 Gliome hémisphérique haut voir fig 14b



Fig 17 Gliome hemisphérique bas voir fig 14c

Tumeurs du 4ème ventricule (Figs 9a et 10) Dans ce groupe on ne trouve pas de signes artériographiques focaux pour ce qui est des arteres cerebelleuses supérieures On soupçonne la presence de ces tumeurs sur des signes artério graphiques indirects

1 Signes d hypertension dans la fosse postérieure refoulement de la basilaire contre le clivus etirement des cerébelleuses

2 Signes d hydrocéphalie interne etirement des arteres cerebrales poste rieures

Le diagnostic de ces tumeurs est essentiellement posé sur les donnees iodo-ventriculographiques ou pneumographiques



Fig 18 Tumeurs latérales extracérébelleuses (tumeurs basales ou tumeurs de l angle) Exemples de différents types de déformation de l angle B et de surélevation refoulement de l artère cérébelleuse supérieure gauche Disposition en marche d escalier des deux artères cérebelleuses supérieures en (b) qui est le même cas qu en (a)

Tumeurs vermiennes et paravermiennes (Figs 9b, 9c, 9d 11, 12, 13) Elles peuvent ne pas donner d autre deformation des arteres cerébelleuses superieures qu un etirement provoque par le refoulement en avant de l artere basilaire (hypertension dans la fosse postérieure) et l'allongement, par hydrocephalie, de la fourche des cerebrales posterieures C est le cas des tumeurs médianes L'ecartement des branches internes des cerébelleuses inferieures, signalé par d autres auteurs, n a pas ete retrouve dans notre collection

Les tumeurs paramedianes associent aux signes que nous venons de citer un deplacement vers le cote oppose de la branche interne vermienne de l artère cerébelleuse superieure (tumeur paramediane haute) ou de celle de la cérébelleuse inferieure (tumeur basse)

II, *Tumeurs laterales*

Tumeurs intracérébelleuses (*tumeurs hémisphériques*) Elles se caractérisent par la coexistence de signes artériographiques d hypertension dans la fosse postérieure et de signes de lateralisation Ces derniers sont (1) les branches terminales de la cérebelleuse supérieure homolaterale sont deviees vers la ligne médiane sur les vues de face, l angle B, que forme cette artere en contournant la protubérance apparait plus aigu que celui du coté opposé, (2) la branche interne de la cerébelleuse inferieure peut eventuellement etre repoussee vers le coté sain

Enfin, suivant que le développement de la tumeur se fait dans la partie haute ou basse de l hemisphere, on observe l existence de signes focaux, intéressant le mode de ramification de la branche latérale (hémisphérique) de la cerebelleuse superieure ou de celle de la cerébelleuse inferieure (Figs 14 15 16, 17)

Tumeurs extracérébelleuses La déformation caractéristique des *tumeurs basales* (tumeurs de l angle pontocérébelleux — Figs 18, 19, 20, 21, 22) concerne l angle B de l artere cerébelleuse superieure correspondante sur les clichés de face



Fig 19 Neurinome de l angle droit Le schema 18a est le calque inverse de cette figure



Fig 20 Même malade que sur fig 19



Fig 21 Neurinome de l angle droit



Fig 22 Neurinome de l angl voir aussi fig 18d



Fig 23 Choléstéatome de l angle droit Le schéma 18c est le calque inversé de cette figure

Cet angle est soulevé et apparait arrondi Il s agit là d une déformation focale, precoce et caractéristique des tumeurs de l angle (qui sont extraparenchymateuses), qu'il differencie des tumeurs intracérébelleuses hemispheriques Ce signe faisait defaut une fois sur les 14 cas de tumeurs de l angle que comporte notre série On le retrouve de profil sous forme d une dénivellation en marche d escalier d'une artere cérebelleuse supérieure par rapport a l autre

Dans les tumeurs volumineuses de l'angle, les segments C et A de l artère cerebelleuse superieure et meme l'artère cérébrale posterieure homolatérale suivent ce déplacement en dedans et en haut Enfin l artere basilaire peut etre, elle aussi, refoulee vers le cote oppose

Les tumeurs *supérieures* et les tumeurs *postérieures* refoulent l hémisphère cérébelleux et impriment ainsi a l artere cérebelleuse supérieure homolatérale des deformations en bloc, s apparentant à celles décrites pour les tumeurs intracérébelleuses hemisphériques

RÉSUMÉ

Les déformations de l artère cérébelleuse supérieure ont une grosse importance pratique dans le diagnostic des processus expansifs sous tentoriels, qu on retrouve dans les tumeurs de l angle et les tumeurs intracérébelleuses hémisphériques et paravermiennes les déformations à distance témoignent l existence d une hypertension dans la fosse postérieure l artériographie vertébrale permet dans un nombre élevé de cas d établir un diagnostic précis de siège et de nature du processus expansif au point que l artériographie vertébrale mérite bien d être faite en premier et souvent comme seul examen neuroradiologique de contraste chez des sujets suspects d avoir une tumeur de la fosse postérieure

SUMMARY

Deformations of the superior cerebellar artery are of considerable practical value in the diagnosis of infratentorial expansive processes and enable tumours of the pontocerebellar angle intracerebellar tumours and those near the vermis and remote deformations causing increased pressure in the posterior fossa to be differentiated Vertebral angiography generally produces an accurate diagnosis of the site and nature of the expansive process It is therefore the method of choice and often the only one necessary in cases of probable posterior fossa tumour

ZUSAMMENFASSUNG

Verschiebungen der Arteria cerebellaris superior sind von grosser diagnostischer Bedeutung bei der Diagnose von infratentorialen raumbeengenden Prozessen und erlauben die Differentialdiagnose von Tumoren des Kleinhirnbruckenwinkels intracerebellaren Tumoren Tumoren des Vermis sowie fernliegenden Geschwulsten die erhöhten Druck in der hinteren Schadelgrube bedingen Die vertebrale Angiographie ermöglicht im Allgemeinen eine genaue Feststellung von Sitz und Art der Erkrankung Sie ist daher die Methode der Wahl und oft die allein notwendige Untersuchungsmethode in Fallen von Erkrankung der hinteren Schädelgrube

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LOCAL AND GENERAL SPASM IN THE INTERNAL CAROTID SYSTEM FOLLOWING TRAUMA

by

HANS FREIDENFELT and ROLF SUNDSTROM

Intracranial arterial spasm is not uncommon in connection with a recent subarachnoid hemorrhage due to the rupture of an aneurysm, as described by several authors (e g NORLEN LINDGREN) This arterial contraction may be well demonstrated by repeated cerebral angiographies (ECKER & RIEMENSCHNEIDER)

Similar arterial spasm may be evident in other conditions Trauma as the causal agent will be considered in this communication, and, as it appears from the literature that this aetiology is not generally recognized, some case reports are presented

In the first two cases the arterial spasm was associated with subarachnoid bleeding

Case 1 A man of 32 was hit on the head by a ball during a game became unconscious and developed hemiplegia Lumbar puncture was performed the same day and the cerebrospinal fluid was markedly blood-stained

Cerebral angiography was performed 9 days later (Fig 1a) Spasm was demonstrated and was still present although reduced a week later (Fig 1b) Three weeks later the vessels were of normal width (Fig 1c) The condition of the patient had also improved and he later recovered completely Carotid angiography on the other side and vertebral angiography revealed no changes

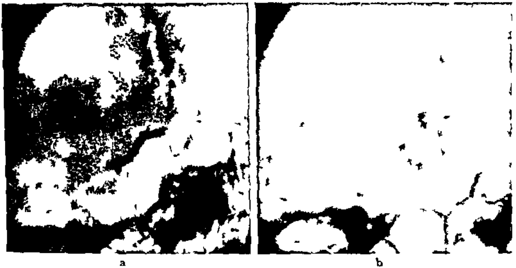




Fig 1 Case 1 a) Severe spasm of the intradural part of the internal carotid artery as well as of the anterior and middle cerebral arteries b) One week later the spasm is reduced c) Three weeks later normal angiogram

A subdural hematoma is also sometimes accompanied by arterial spasm

Case 2 A woman of 61 developed hemiplegia 14 days following a head injury sustained in a road traffic accident

At cerebral angiography an extra cerebral hematoma in the frontoparietal region with spasm was evident (Fig 2a) Further angiography a month later showed that the spasm had disappeared (Fig 2b)

Due to several circumstances the patient was not operated upon until 2 weeks after the second examination

Case 3 A man of 57 fell from a height of about 1 meter and hit the back of his head Next day he was brought to hospital following an epileptic fit Lumbar puncture was performed and no blood was found in the cerebrospinal fluid



a b

Fig 2 Case 2 a) Spasm of the intracranial part of the internal carotid artery and of the first part of the anterior and middle cerebral arteries b) One month later no spasm



a b

Fig 3 Case 3 a) Displacement of the first part of the pericallosal artery posteriorly and local spasm of the anterior cerebral and pericallosal arteries b) Pericallosal artery still somewhat displaced but no spasm

Cerebral arteriography one week after the injury demonstrated an expansive process in the frontal region and local spasm of the anterior cerebral and pericallosal arteries (Fig 3a) A second examination was performed a month later (Fig 3b) The expansive process was rather smaller but the spasm had completely disappeared The epileptic fits had also subsided

Encephalography 14 days after the injury clearly showed that the expansive process lay in the frontal lobe the location of the process corresponded to that of the contracted vessels

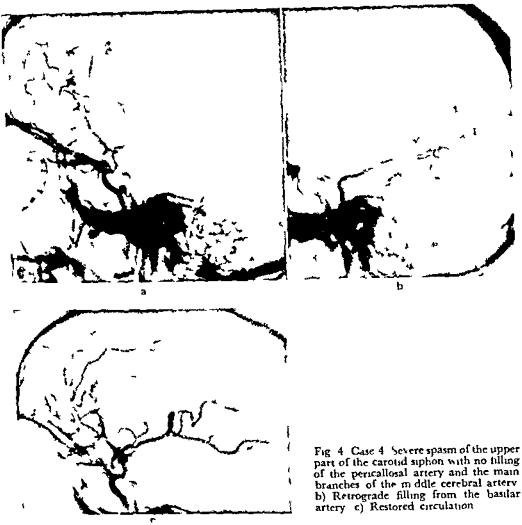


Fig 4 Case 4 Severe spasm of the upper part of the carotid siphon with no filling of the pericallosal artery and the main branches of the middle cerebral artery b) Retrograde filling from the basilar artery c) Restored circulation

The above cases had head injuries accompanied by intracranial bleeding of one type or another Arterial spasm occurred without any demonstrable intracranial hemorrhage in the following 2 cases

Case 4 A girl aged 13 years fell hit her forehead and developed hemiplegia and Babinski sign Lumbar puncture the same day showed nothing abnormal no blood was found

Cerebral arteriography performed 4 weeks later showed extreme spasm of the upper part of the carotid siphon and its main branches (Fig 4a) Rapid serial vertebral angiography (Fig 4b) demonstrated that the main branches of the internal carotid artery were filled from the basilar artery in a retrograde direction

Fourteen months later (Fig 4c) the siphon was of ordinary width and the pericallosal artery and the main branches of the middle cerebral artery were filled with contrast medium



a b

Fig 5 Case 5 a) Spasm of the carotid siphon the branches of the middle cerebral artery are only partially filled b) One month later no spasm conspicuous difference in filling of the branches of the middle cerebral artery

these vessels were also normal in width However the patient still had hemiplegia and epilepsy of the Jacksonian type had also appeared

At encephalography another 10 months later atrophy of the right hemisphere mainly of the temporal lobe was found

Case 5 A boy who had previously been healthy was at the age of 18 examined in hospital after having been found on the street with hemiplegia and motor and sensory aphasia The cerebrospinal fluid was clear

Carotid arteriography after about 3 weeks revealed spasm of the carotid siphon (Fig 5a) A month later the spasm had almost completely disappeared (Fig 5b) Encephalography 14 days after the initial signs was normal but two months later central atrophy developed on the affected side

The clinical signs are still present today 8 years later The patient s statement that he had hit his head has not been verified as there was no witness to this but since extensive clinical and laboratory investigations have failed to give any other possible explanation it seems likely that the boy had sustained a head injury before the onset of his illness

Discussion

All but one (Case 3) were examined on both sides, in 2 of these cases bilateral carotid angiography was performed on the same day but the arterial spasm was evident only on one side It would appear that the possibility of a faulty examination technique may be excluded an opinion that is supported by the fact that no aggravation of the signs developed in connection with the angiography The last two cases, unlike the rest, had no known intracranial bleeding Both were young subjects and neither had signs of primary vascular disease

SUMMARY

Local or more general intracranial arterial spasm may appear after a head injury with or without intracranial bleeding The arterial contraction may persist for a long period and eventually produce a definite brain lesion

ZUSAMMENFASSUNG

Schadelverletzungen konnen lokalen oder allgemeinen Gefäss-spasmus hervorrufen der mit intrakranieller Blutung verbunden sein kann oder nicht Der Arterien spasmus kann lange andauern und bleibende Gehirnschadigung herbeifuhren

RÉSUMÉ

Un spasme artériel intracranien local ou assez étendu peut apparaitre après un traumatisme cranien qu il y ait ou qu il n y ait pas d hémorragie intracranienne Le spasme artériel peut persister pendant une longue période et causer éventuellement une lésion cérébrale

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FROM THE ROENTGEN DEPARTMENT (DIRECTOR PROF ERIK LINDGREN), SERAFIMER LASARETTET, STOCKHOLM, SWEDEN

THE POSTERIOR INFERIOR CEREBELLAR ARTERY

by

T GREITZ and S E SJOGREN

Vertebral angiography is generally considered less adequate in the diagnosis of tumors than carotid angiography The posterior inferior cerebellar artery and its branches are generally considered to be of great importance in the localization of posterior fossa tumors, although they appear to have received little attention in the radiologic literature

In spite of the many variations of this artery, HAUGE (1954) gave an account of a standard course with a caudal loop lying at the lower part of the tonsil and a cranial loop coinciding with its upper border This author under the heading 'anatomical and angiographic variations described only two cases in which the artery crossed the mid line

KRAYENBUHL & YASARGIL (1957), in their monograph on vertebral angiography included schematic drawings of anatomical variations in the course of the posterior inferior cerebellar artery They did not, however, relate these variations to the surrounding structures, and no clear concept *of their significance* is therefore possible The descriptions of the posterior inferior cerebellar artery, met with in the anatomical literature are not applicable to radiologic work and we have therefore undertaken a study of both the anatomical and the roentgenologic aspects of this artery

Material and Methods This investigation was based upon a material consisting of 30 half brain specimens injected with a gelatine barium sulphate suspension and *100 vertebral angiographies in cases without clinical or roentgenologic* signs of an expanding or atrophic intracranial lesion Thirty of these 100 cases

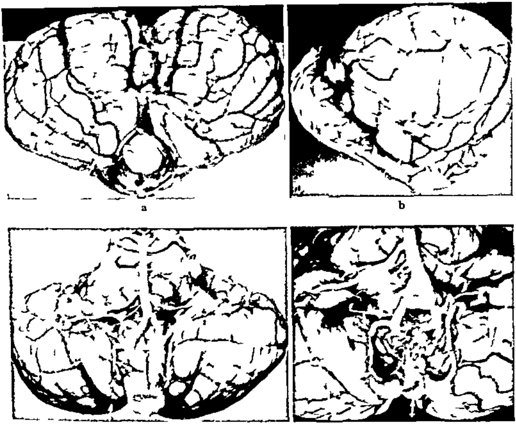


Fig 1 Topography of tonsil (→) uvula (↔) and posterior inferior cerebellar artery (↔) a) Posterior b) lateral c) and d) infer or aspects The medulla has been removed in (d) the transition between the dorsal and the basal areas of the medial surface is marked in (a) with an arrow (>→)

had been subjected to encephalography and a comparison was made between the angiographic and pneumographic findings The autopsy material was submitted to dissection photographic registration and roentgen examination

The pathologic material upon which this study was based consisted of 12 cases of the Arnold Chiari malformation and 61 cases of tumors of the posterior fossa Examinations of unsatisfactory quality and cases operated upon as well as cases of vascular malformations and supratentorial tumors have been excluded

Results

Autopsy studies normal anatomy The posterior inferior cerebellar artery usually supplies the inferior posterior quarter of the cerebellar hemisphere including

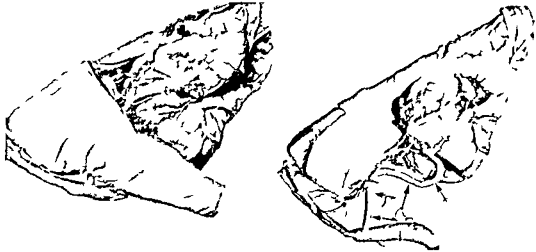


Fig 2 Specimen from the medial aspect before and after removal of the medulla Cisternal part (→) medullary part (→→) and choroid arch (→→→) from which the relationship to fourth ventricle and choroid plexus may be observed

the tonsil, the plexus of the fourth ventricle and the inferior part of the vermis The topography of the tonsil from the posterior, lateral and inferior aspects is shown in Fig 1 The medial surface of the tonsil may be divided into two parts due to fact that the tonsil embraces the medulla A basal, concave part faces medially and inferiorly towards the medulla and a dorsal, slightly convex area, is directed towards the corresponding surface of the opposite tonsil The wedge shaped lower border of the uvula is located between the dorsal parts of the tonsils After the medulla has been removed (Fig 1d) it becomes evident that, with the exception of its proximal portion the trunk of the posterior inferior cerebellar artery lies upon the medial surface of the tonsil like all other main arteries of the brain, it courses over the surface of the cerebral structures

The proximal portion of the artery, located within the basal cisterns we call the cisternal part (Fig 2) It is followed by the medullary part, which is located within the fissure between the medulla and the concave surface of the tonsil The medullary part usually continues upwards to form a bow, which gives off twigs to the anterior part of the tonsil and to the choroid plexus, and which may or may not be identical with the so called cranial loop of the main trunk That part of the vessel which supplies the plexus we call the choroid arch

The autopsy material in a preliminary survey could be divided into three groups according to the origin and course of the cisternal part of the artery (Fig 3) In the first group, consisting of 12 cases it arose from the vertebral artery and approached the posterior pole of the tonsil and in the second group consisting of 10 cases, it had the same origin but reached the anterior pole of the tonsil In the third group, which included 6 cases, it emerged



Fig 3 Variations in origin of the poster or inferior cerebellar artery In the upper v ew it arises from the vertebral artery on the l ft side (r ght n the figu e) and approaches the posterior pole of the tons l (type I) in the lo er view it approaches the anterior pole on the left side (type II) and on the right side it emerges from the basilar artery (type III) It is absent on the right s de in the upper view the anterior inferior cerebellar artery on th same s de being large

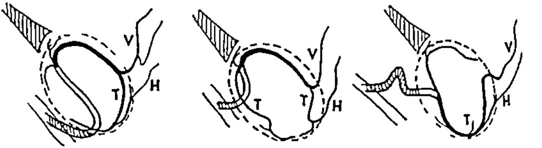


Fig 4 Schematic drawings showing the appearances of the three main types of variations in origin of the posterior inferior cerebellar artery in the lateral projection Dotted line is tonsil and hatched area fourth ventricle Origin of hemispheric (H) vermis (V) and tonsillar (T) branches are depicted.

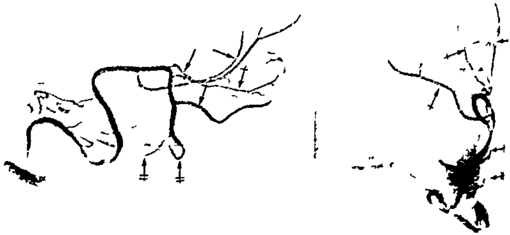




Fig 5 Autopsy specimen Appearance of the type I variation in the lateral half axial and axial projections respectively Vermis vessels (→) hemispheric branches (⇸) and tonsillar branches (⇻)

from the basilar artery and reached the anterior pole of the tonsil The posterior inferior cerebellar artery was absent in two cases although the vertebral artery was present

Both the cisternal and medullary parts were longer in cases of the first type than in cases of type II (Fig 4) In the third group the medullary part of the







Fig 6 Autopsy specimen Appearance of the type II variation in the lateral half axial and axial projections respectively Vermis vessels (→) hemispheric branches (+→) and tonsillar branches (↔)

artery usually continued posteriorly below the tonsil to terminate in branches to the vermis and the hemisphere it gave only a minor branch or small twigs to the choroid plexus The tonsil in the first two groups was mainly supplied by branches which approached it from above in the third group it was mainly fed from below The vermis branches in types I and II arose in most cases from the choroid arch but in cases of type III they usually emerged from the medullary part after it had curved around the inferior pole of the tonsil Most hemispheric branches were given off from the same trunk as the tonsillar vessels

The cisternal part in type I was long this being clearly evident in the lateral and submentovertical projections (Fig 5) The same was true of the

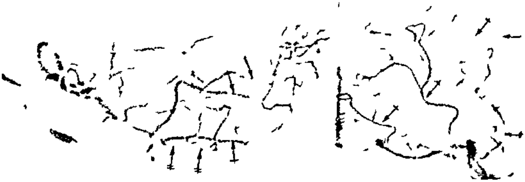




Fig 7 Autopsy specimen Appearance of the type III variation in the lateral half axial and axial projections respectively Vermis vessels (→) hemispheric branches (⇸) and tonsillar branches (⇻)

medullary part this outlined the medulla in the half axial projection The choroid arch curved close to the posterior border of the fourth ventricle The vermis branches defined the inferior posterior part of the vermis, and were situated in the midline The tonsillar branches curved around the inferior posterior pole of the tonsil and had the same origin as most of the hemispheric branches

In type III the cisternal part of the artery, which had a course similar to that of the anterior inferior cerebellar artery, was further from the midline than in the preceding groups (Figs 5 6 and 7) Uniformly consistent differences between the three groups could not be observed however and combinations of the different origins and courses of the posterior inferior cerebellar artery and its branches as well as extensions over the midline constituted the basis for a wide range of anatomical variations, this was especially noticeable as regards the choroid arch A detailed description of all the variations observed would however be beyond the scope of this paper



Fig 8 Vertebral angiography normal material Appearances of the type I and type II variations in the lateral projection



Fig 9 Normal case type I variation A loop of the cisternal part of the artery hangs down below the foramen magnum

Angiographic findings normal anatomy A study of vertebral angiographies in normal cases revealed basically the same anatomical variations as in the autopsy specimens

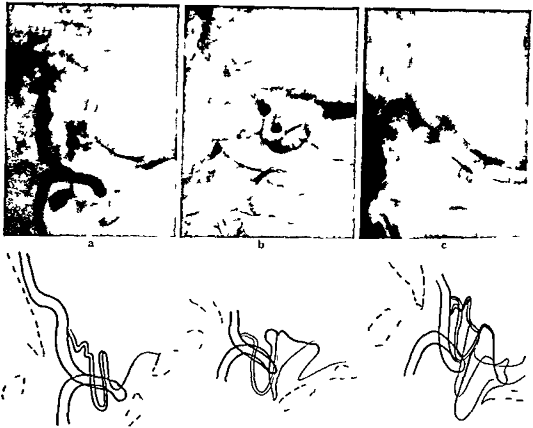


Fig 10 Vascular changes in 3 cases of Arnold Chiari malformation The double lines in the explanatory sketches denote main trunk the filled in lines below foramen magnum indicate tonsillar branches

In 100 angiographies, a posterior inferior cerebellar artery of type I was found in 43 cases of type II in 40 cases, and of type III in 7 cases The artery in the remaining 10 cases was absent or impossible to identify Fig 8 shows the appearances of type I and type II variations in vertebral angiography

In 17 of the 43 cases belonging to type I, the cisternal part of the main trunk, but no other parts of the artery, was located up to 13 mm below the level of the foramen magnum although no displacement of the tonsils could be observed at encephalography (Fig 9)

Although intermediate types were found, the distinction between the three main groups helped to identify the different parts of the artery and the position of the tonsil and the inferior part of the vermis could usually be determined when this identification had been made An evaluation of displacements in the inferior posterior part of the posterior fossa should thus be possible

Angiographic findings, pathologic material The characteristic change in the posterior inferior cerebellar artery in the Arnold Chiari malformation is said



Fig 11 Meningeoma from the clivus The choroid arch (arrow) as well as the basilar artery displaced posteriorly

to be a loop hanging down below the foramen magnum Our anatomical investigations have shown this to be a normal anomaly involving the cisternal part of the trunk This change, although not pathognomonic, is more frequently evident however in the Arnold Chiari malformation It was present in 9 out of the 12 cases examined The tonsillar branches in 10 cases could be observed up to 20 mm below the foramen magnum (Fig 10) This is a finding that indicates downward displacement of the tonsil Furthermore in 9 of the 12 cases the choroid arch was definitely displaced downwards and in one of these cases the cisternal part of the artery was found below the foramen magnum without displacement of the tonsillar branches

Only the tonsillar branches extended below the foramen magnum in 2 cases (Fig 10c) In one case of the twelve the posterior inferior cerebellar artery was absent In spite of this a definite staining of the tonsil was obtained probably from branches arising directly from the cranial part of the vertebral artery in the neck Displacement of the tonsil could thus be observed in all the cases of Arnold Chiari malformation examined

All the changes evident in the Arnold Chiari malformation may also be observed in a herniation of the tonsil (Fig 13) It does not seem possible to distinguish between these two conditions by the shape of the vessels displaced below the foramen magnum The difference lies in the presence in case of a herniation of signs of an expanding lesion

Generally speaking it may be said that in the case of an expanding lesion the posterior inferior cerebellar artery moves with the tonsil Small tumors



Fig 12 Tumor of the cerebellar hemisphere growing into the pontine angle The lateral projection shows that the posterior inferior cerebellar artery is filled on both sides and there is a bilateral posterior shift of the choroid arch It is evident from the displacement of the anterior inferior cerebellar artery (→) that the tumor is on the right side Lateral displacement to the left of the tonsillar branch (+→) but no displacement of the vermis branch (++→)

situated high up do not therefore produce any changes in the posterior inferior cerebellar artery In the case of a tumor arising basally in the midline such as a pontine or a clivus tumor, the tonsil, and consequently the posterior inferior cerebellar artery, are displaced backwards (Fig 11) There is usually

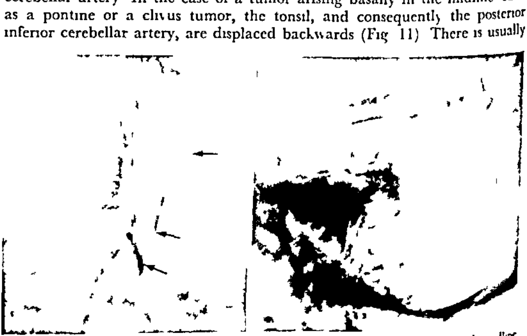


Fig 13 Tumor of the cerebellar hemisphere Marked displacement of the vermis vessel over the midline seen in the frontal projection (arrows in left view)



Fig 14 Vermis tumor Marked depression of the choroid arch and the vermis vessels which are not laterally displaced to any significant degree (→) *Tonsillar herniation with caudal displacement of tonsillar branches is present* (→→)

no displacement of the vermis or the tonsillar branches across the midline

Tumors within the medulla oblongata often grow into the pons and give rise to changes similar to those found with pontine tumors A local deformity of the medullary part describing a wider and longer curve than normally, was observed in one case of such a tumor

Large pontine angle tumors may cause a posterior displacement of the choroid arch, this was evident in 4 out of 19 cases in our material A lateral shift of the posterior inferior cerebellar artery across the midline is occasionally observed and displacement of the tonsillar branches seems to be more marked than that of the vermis branches In two cases an upward displacement of the cisternal part of the artery was present

Extra and intracerebellar tumors within the pontine angle give rise to the same changes in the posterior inferior cerebellar artery If large they displace the choroid arch posteriorly and cause lateral displacement of the tonsillar branches and less frequently, of the vermis vessels as well The local deformity of the vessels in the tumor area is however different in the two types of tumor (Fig 12)

Tumors of the cerebellar hemisphere frequently cause herniation of the tonsil In 7 of our 15 cases a displacement of the vermis branches across the midline could be observed Furthermore the choroid arch may be displaced anteriorly and may also be locally deformed by tumors that approach the midline (Fig 13)

Tumors of the vermis produce less lateral displacement but otherwise cause the same changes as hemispheric tumors (Fig 14)



Fig 15 Ependymoma of the fourth ventricle The choroid arch is displaced downwards and flattened (arrow)

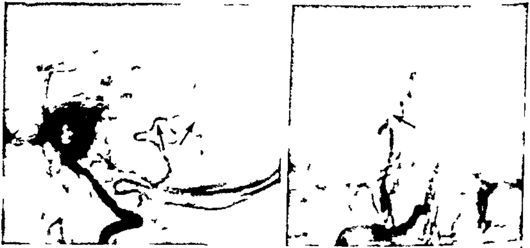


Fig 16 Angioreticuloma growing out from the medial surface of the tonsil The choroid arch is widened and displaced upwards as well as laterally (arrows)

Fourth ventricular tumors actually include several disparate growths tumors arising from the choroid plexus from the medulla and the pons, and from the vermis The changes in the posterior inferior cerebellar artery that are seen in these cases depend upon the origin and the direction of growth of the tumor If the tumor originates from the floor of the fourth ventricle, the changes may be similar to those with pontine tumors When a tumor grows out towards the pontine angle the appearances are those of an angle tumor If a tumor grows out posteriorly between the tonsils the changes

may be similar to those with a vermis tumor Tumors arising from the choroid plexus may displace the choroid arch downwards and deform it (Fig 15)

Tumors within the tonsil increase its volume and separate the vessels around it, and consequently the choroid arch may be displaced upwards These tumors also cause a lateral displacement which may be towards the side of the tumor if the tumor grows out from the medial surface of the tonsil between the loops of the posterior inferior cerebellar artery (Fig 16)

Conclusions

These investigations have shown that the posterior inferior cerebellar artery and its branches although subject to numerous variations has a constant relationship to certain brain structures This concept enables a more accurate angiographic diagnosis in cases of displacement of the posterior part of the posterior fossa, such as cases of Arnold Chiari malformation and tumors displacing the tonsil

SUMMARY

The anatomy of the posterior inferior cerebellar artery was studied at autopsy by dissection and postmortem angiography and at vertebral angiography in living subjects under normal and pathologic conditions The artery has a constant relationship to certain brain structures which facilitates an accurate diagnosis in expanding lesions affecting the tonsillar region The angiographic findings in tumors of varying location tonsillar herniation and the Arnold Chiari malformation are described

ZUSAMMENFASSUNG

Die Anatomie der Arteria cerebellaris posterioris inferioris wurde am Sektionspraparat und mit Hilfe von Angiographie an der Leiche studiert und mit angiographischen Befunden am Lebenden unter normalen und abnormalen Bedingungen verglichen Die Arterie hat konstante Beziehungen zu gewissen Gehirnteilen die zur exakten Diagnose von Erkrankungen der Kleinhirntonsillengegend fuhren Angiographische Befunde bei Tumoren dieser Gegend bei Tonsillenhernie und der Arnold Chiari Missbildung werden angefuhrt

RÉSUMÉ

L anatomie de l artere cérébelleuse posterieure et inferieure a eté étudie par dissection et par angiographie post mortem et par angiographie vertébrale chez des sujets vivants dans des etats normaux et pathologiques Cette artère a des rapports constants avec certaines structures nerveuses qui facilitent le diagnostic exact de lesions expansives de la region des amygdales cérébelleuses Les auteurs décrivent les signes angiographiques de tumeurs de localisations diverses de la hernie des amygdales cerebelleuses et de la malformation d Arnold Chiari

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ANGIOGRAPHIC STUDIES OF THE BLOOD FLOW IN THE CIRCLE OF WILLIS

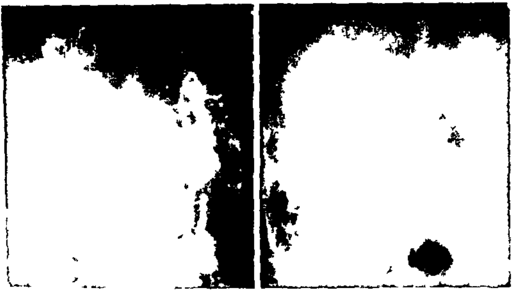
The value of various arterial compression tests

by

GORDON L GRYSPEERDT

Angiographic study of the alterations in the blood flow through the circle of Willis with various arterial compression tests is not only of academic interest but may have considerable practical importance in the pre operative assessment of certain intracranial lesions amenable to surgery Thus for example, the information gained by altering the pressures within the vessels comprising the arterial circle, by compression in the neck of one or more of the main arteries supplying the brain during angiography may be of vital importance in planning the technique for the surgical treatment of intracranial aneurysms

Interpretation of the appearances at angiography is complicated by the high incidence of anatomical anomalies in the arterial circle and the anatomical studies of ALPERS BERRY and PADDISON of MOREL and WILDE of KLEISS and of many other authors have shown that anomalies exist in the anatomical conformation of the circle of Willis in 50 % to 80 % of the material studied by these investigators The anomalies are mainly composed of marked variation in the size of the posterior communicating and anterior cerebral arteries on the two sides within the arterial circle but with about 10 % incidence of more major anomalies including interruption of the arterial circle anteriorly or posteriorly in about 2 % of the material



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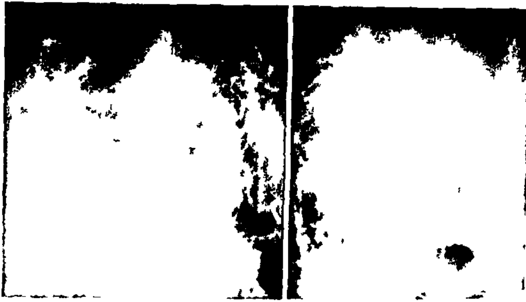
Fig. 1. Male aged 40 years with primary subarachnoid haemorrhage 4 days prior to angiography. a) Left oblique projection. Aneurysm at origin of anterior communicating artery; both anterior cerebral arteries outlined distal to the arterial circle; no spasm in the vessels. b) Right half axial projection with left carotid compression. Spasm in right internal carotid artery and small calibre of right anterior cerebral artery in arterial circle; no cross-flow.

Anterior part of circle of Willis

All neuroradiologists are familiar with the frequent demonstration of cross-flow via the anterior communicating artery with compression of the contralateral carotid artery in the neck. The importance of demonstrating a free passage through the anterior communicating artery in those cases where there is a risk of interference with the normal blood supply has been stressed by SALTZMAN (1959). Certain neurosurgical techniques in the surgery of intracranial aneurysms are deliberately planned to alter the pressure in the sac of the aneurysm by surgical interference with the normal blood supply, and in these cases the pre-operative demonstration of the alterations in the blood flow within the arterial circle during arterial compression tests is especially valuable.

Assessment of arterial spasm. Marked difference in the calibre of the two anterior cerebral arteries within the arterial circle is not uncommonly seen at routine bilateral carotid angiography, but in the presence of recent subarachnoid haemorrhage in the region of the circle of Willis arterial spasm may mask the true anatomy.

An example of this problem, not uncommonly encountered in the investi



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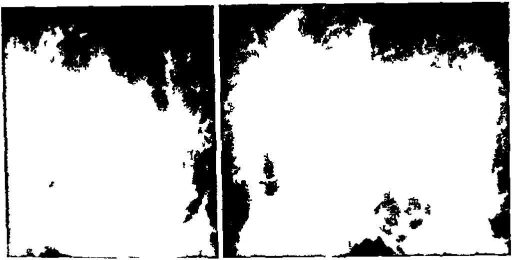
Fig. 2 Same case as in fig 1 Repeat angiograms after 8 days a) Left oblique projection Size of sac of aneurysm now apparently larger no spasm in vessels b) Right half axial projection with left carotid compression Spasm in right internal carotid artery is partially relaxed calibre of right anterior cerebral artery remains small no cross flow

gation of aneurysms on the anterior part of the arterial circle, is illustrated in Fig 1 In this patient an aneurysm at the junction of the anterior communicating and anterior cerebral arteries on the left side (Fig 1a) was seen at carotid angiography performed four days after a primary subarachnoid haemorrhage The right anterior cerebral artery was of small calibre and there was demonstrable spasm in the right internal carotid artery There was no cross-flow with compression of the left carotid artery in the neck (Fig 1b)

A further carotid angiogram obtained eight days later showed partial *relaxation of the spasm in the right internal carotid artery* but the calibre of the right anterior cerebral artery remained small and there was still no cross flow with carotid compression (Fig 2b) In view of the large calibre of the left anterior cerebral artery (Fig 2a) it was felt that the appearances were more likely to be due to an anatomical variant in the anterior part of the circle of Willis

However, a further carotid angiography performed six weeks later (*Fig 3*) showed equality in size of the anterior cerebral arteries and good cross flow via the anterior communicating artery with left carotid compression

The surgical management of an aneurysm in such a site will be influenced by the contribution to the blood flow in the anterior part of the circle of

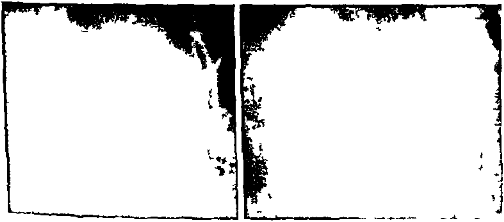


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Fig 3 Same case as in figs 1 and 2 Repeat ang ograms after 6 weeks a) Left oblique projection Size of sac of aneurysm apparently further enlarged no spasm in vessels b) Right half axial projection with left carotid compress on Good cross flow into right anterior and middle cerebral arteries no spasm in vessels anterior cerebral arteries of equal calibre

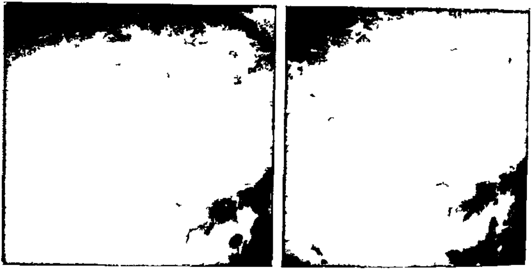
Willis from both sides, and assessment on a single angiographic examination following a recent subarachnoid haemorrhage may be misleading

Pre operative and post operative assessment of cross flow An aneurysm at the junction of the anterior cerebral and anterior communicating arteries is not



a b

F 4 Female aged 54 years a) Pre-operative left arter ogram w th ght carotid comp ess on The aneurysm at the junction of right pericallosal and anterior commun cating arteries is outlined by c oss-flow through the anterior communicating a tery b) Po toperati e left arteriogram Cl p across the right anterior cerebral artery proximal to the aneurysm appearan es almost ident cal with the preoperat e arteriogram with right carot d comp ess o



a b

Fig 5 Male aged 49 years Bilateral carotid arteriograms a) Left lateral projection Aneurysm outlined on anterior part of arterial circle both pericallosal arteries arise as a common trunk filling from the left side b) Right lateral projection Only the right fronto polar and right calloso marginal arteries arise from the anterior part of the arterial circle the aneurysm is not outlined

infrequently outlined by cross filling with carotid compression on the same side as the aneurysm and in these cases, judged purely from the angiographic appearances clipping of the anterior cerebral artery proximal to the aneurysm would appear to be of limited therapeutic value In our small series of post operative angiograms performed some weeks after clipping the anterior cerebral artery in such cases the sac of the aneurysm has been shown unaltered or enlarged in size in every case An example is illustrated in Fig 4 A large series of such cases showing pre operative cross flow with contrast filling of the aneurysm must, of course be obtained before statistical inference can be drawn

Failure to obtain cross flow Absence of the anterior communicating artery is shown to be uncommon from the anatomical studies and failure to obtain cross flow through this vessel, by contra lateral carotid compression is more likely to be due to equalisation of the pressures on the two sides of the arterial circle by forward contribution through the posterior communicating artery on the side of the arterial compression In the presence of an aneurysm, spasm in the anterior part of the arterial circle may be the cause of failure to demonstrate cross flow There is, however one not very uncommon anatomical anomaly in which congenital interruption of the circle of Willis may at least be suspected In this anomaly only the fronto-polar and calloso-marginal arteries supplying one hemisphere arise from one side of the arterial circle anteriorly whilst on the other side both pericallosal arteries arise as one common arterial trunk In a series of one thousand consecutive bilateral carotid angio-



a b

Fig 6 Same case as in fig 5 a) Left half axial projection Distribut on to both hemispheres b) Right half axial project on ith left carotid compression No cross-flow the aneurysm is not outlined

graphies this type of anatomical anomaly was seen seven times but varying in the extent of distribution of the vessel common to both hemispheres An example of this anatomical variant occurring in a case with a demonstrable aneurysm on the anterior part of the arterial circle, is illustrated in Fig 5 In this case there was no cross flow through the anterior part of the circle of Willis with carotid compression tests (Fig 6) A repeat bilateral carotid angiogram after six weeks yielded the same result

Some of the more extensive anatomical anomalies occurring in the circle of Willis have recently been reviewed by BERK and he points out that aneurysms on the arterial circle appear to occur more frequently in the presence of ana tomical anomalies Although this is a generally accepted finding it is difficult to assess the increased incidence statistically by cerebral angiographic methods owing to the essentially selective nature of this type of investigation

Posterior part of circle of Willis

Adequate study of alterations in the blood flow in the posterior communi cating arteries by arterial compression methods has as yet received little attention mainly due to the lack of a generally accepted simple technique and the absence of obvious or definite clinical indications for this type of in vestigation Reversal of the blood flow in the posterior communicating artery

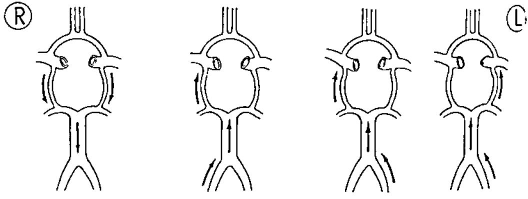


Fig 7 Blood flow in the circle of Willis with various arterial compression techniques

by arterial compression methods has been reported by KRAYENBUHL and YASARGIL, and by SALTZMAN (1959), on small numbers of cases In another comprehensive paper, SALTZMAN (1959) has reviewed, by retrospective research the filling of the posterior communicating arteries by routine carotid and vertebral angiography By inference, it is clear from the published work that routine carotid and vertebral angiography performed on the same patient does not always give full demonstration of both posterior communicating arteries This has also been our experience, especially in the investigation of subarachnoid haemorrhage

If the posterior communicating artery on one or both sides is outlined by routine vertebral angiography, the contrast filling is usually inadequate to identify the junction of this vessel with the internal carotid artery If in the same case there is no filling of one or both posterior communicating arteries by bilateral carotid angiography, the assessment of the arterial circle by cerebral angiography is incomplete The possibility that a surgically treatable aneurysm might be present at the origin of the posterior communicating artery from the internal carotid artery, but only demonstrable due to a recent subarachnoid haemorrhage by forward filling of the posterior communicating artery, was our justification for submitting in the first instance a series of selected cases with subarachnoid haemorrhage and negative findings at bilateral carotid angiography to a specialised form of vertebral angiography

The choice of technique Some of the methods available for outlining the posterior communicating artery by altering the pressures in the anterior and posterior parts of the circle of Willis are illustrated in Fig 7 We have found bilateral

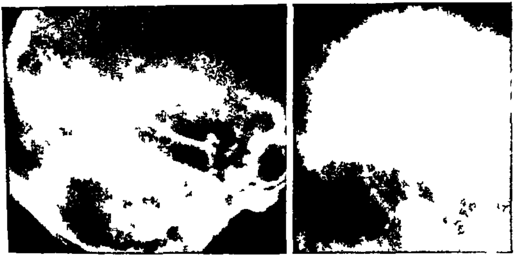
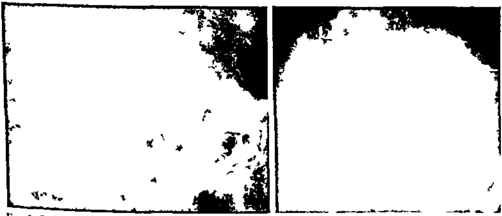


Fig 8 Female aged 30 years with proven subarachnoid haemorrhage 10 days prior to vertebral angiography (Negative bilateral carotid angiography) Vertebral arteriograms by catheterisation alternating bi plane exposures. Posterior communicating arteries outlined but inadequate for full study

vertebral artery compression in the base of the neck with injection of the contrast medium into the carotid artery unreliable as a routine procedure due to the difficulty of preventing unintentional carotid artery compression at the same time

Ipsi lateral carotid artery compression distal to the injection site on the right side has been used at this centre as a routine procedure in carotid angiography for the investigation of subarachnoid haemorrhage The filling of the branches of the basilar artery with the contrast medium is however often inadequate by this method, if one takes filling of the posterior choroidal



F g 9 Same ca e as in fig 8 Vertebral arteriograms with l ft carot d compress on Good fill ng of l ft posterior communicating a tery with forward flow into left carot d s phon and left middle cerebral artery

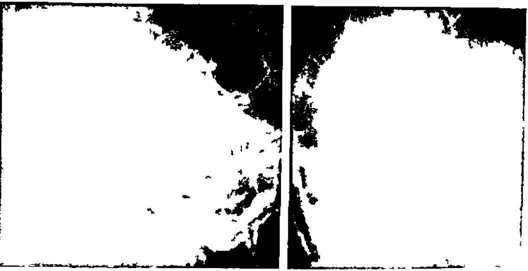


Fig 10 Same case as in figs 8 and 9 Vertebral arteriograms with right carotid compression Good filling of right posterior communicating artery with extensive forward flow into right carotid siphon and right middle cerebral artery the difference in calibre between the posterior communicating arteries is clearly shown

arteries as the criterion, and furthermore this method only allows for reversal of the blood flow in the right posterior communicating artery

Vertebral artery catheterisation was therefore chosen as the routine method of investigation and the percutaneous femoral route, first advocated by LINDGREN, has been used, as this allows for complete freedom in the cervical region to carry out adequate compression of the carotid arteries

In the preliminary series of cases, in order to reduce the number of injections of contrast medium to three, the examination was carried out on the bi plane serial film changer, using alternate lateral and antero posterior exposures for each injection (SOILA) the exposures being made at half second intervals in each plane for two seconds and then at one second intervals for a further two seconds The first injection was given without carotid artery compression but the examination was then repeated with left and then with right carotid artery compression Bi plane exposures however have the disadvantage of slight loss of definition due to the increased object film distance in each plane

Radiographic assessment of compression tests An example of the routine bi plane examination with vertebral artery catheterisation is illustrated in Figs 8, 9 and 10

In this case, a primary proven subarachnoid haemorrhage had occurred ten days prior to the vertebral angiogram and bilateral carotid angiography had shown no causative lesion Only the right posterior communicating artery was outlined at carotid angiography In the vertebral arteriogram, without carotid artery compression (Fig 8) the left posterior cummunicating artery was outlined



a b



c

Fig 11 Female aged 45 years (Right posterior communicating artery of large calibre was outlined at carotid angiography) Vertebral arteriograms a) Forward filling of small left posterior communicating artery b) Right carotid compression Reversal of flow in large right posterior communicating artery the density of the right carotid siphon indicates extensive forward flow c) Left carotid compression Less forward flow as compared with right side due to smaller calibre of left posterior communicating artery

as a vessel of small calibre, but the junction of this vessel with the internal carotid artery was not clearly shown, there was also some faint filling of the right posterior communicating artery indicating reversal of flow in this vessel with vertebral artery injection

In the vertebral arteriogram with left carotid artery compression (Fig 9), the left posterior communicating artery was clearly outlined throughout its length and good contrast filling of the distal limb of the left carotid siphon and the left middle cerebral artery was obtained In the vertebral arteriogram with right carotid artery compression (Fig 10) there was extensive forward flow through the right posterior communicating artery to outline the right carotid siphon and the right middle cerebral artery No aneurysm has been demonstrated in the region of the circle of Willis

Twenty five cases with recent subarachnoid haemorrhage but with negative bilateral carotid angiograms in which one or both posterior communicating arteries had failed to outline, were chosen for this preliminary investigation by vertebral artery catheterisation Satisfactory contrast filling of the basilar artery and its branches was obtained in 17 cases In the remaining 8 cases mainly in the older age group, injection had to be made with the catheter tip in the



Fig 12 Female aged 47 years (Left III nerve palsy no subarachnoid haemorrhage) Left carotid arteriograms Aneurysm arising at the anterior origin of the left posterior communicating artery no filling of this vessel

mouth of the subclavian artery resulting in inadequate contrast filling of the basilar artery for the carotid compression technique

In no case in this series was an aneurysm revealed at the anterior origin of the posterior communicating artery This has been a disappointment but the method has allowed us to study the dynamics of the circle of Willis SALTZMAN has shown by angiographic studies that if the posterior cerebral artery is morphologically a continuation of a posterior communicating artery of large calibre, then the blood flow is usually from the internal carotid artery backwards, whereas if the posterior communicating artery is small then the blood flow in this vessel is usually forwards These angiographic findings were borne out in this small series of vertebral angiographies by catheterisation in which 12 of the 17 cases had posterior communicating vessels of very unequal calibre, but, in addition, it was found that the normal backward flow in a large posterior communicating artery could be reversed by carotid compression in every case No alteration in the calibre of the vessel was found by comparing the appearances of backward and forward flow in the respective carotid and vertebral arteriograms The larger the lumen of the posterior communicating artery the greater appeared to be the extent of the reversal of normal flow as judged by the density of the contrast medium in the carotid siphon An example of this finding is illustrated in Fig 11

The amount of the forward flow through the posterior communicating artery with unilateral carotid artery compression will, of course, be regulated by the amount of cross flow via the anterior communicating artery, and this can be assessed in each individual case by the appearances at the preliminary carotid angiography with contra lateral carotid artery compression

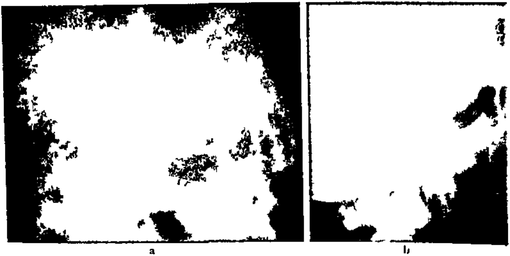
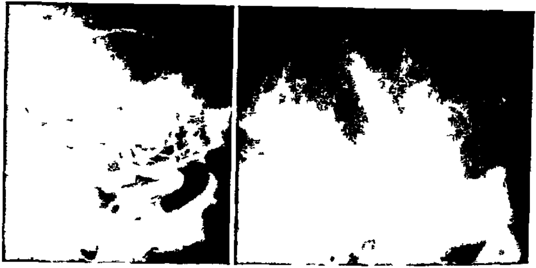


Fig 13 Same case as in fig 12 a) Right carotid arteriogram with left carotid [illegible] cross-flow sac of aneurysm not outlined b) Vertebral arteriogram with left carotid [illegible] forward flow through left posterior communicating artery

By the same reasoning, in those cases which fail to show cro[illegible] anterior communicating artery at carotid angiography with [illegible] compression, and where it may be essential to assess the cause of fa[illegible] planning the surgical technique vertebral angiography with [illegible] compression will indicate the amount of forward flow through [illegible] communicating artery and the behaviour and flow of the contr[illegible] in the anterior part of the arterial circle Failure to obtain cro[illegible] anterior communicating artery, with carotid artery compression, [illegible] to equalisation of the pressures on both sides of the anterior [illegible] artery by extensive forward flow through a large posterior [illegible] artery

Clinical application of compression tests

With the basic information thus acquired by employing [illegible] nique of vertebral angiography in a preliminary series we [illegible] our attention to the further investigation of cases with a posit[illegible] aneurysm at the anterior origin of the posterior commun[illegible] marked variability in the calibre of the posterior comm[illegible] each side has been discussed as this vessel is frequently no[illegible] angiography in the presence of an aneurysm at its anterio[illegible] contribution of blood flow remains unknown unless vert[illegible] carried out If vertebral angiography with carotid arte[illegible] carried out this will simulate the dynamics following [illegible]



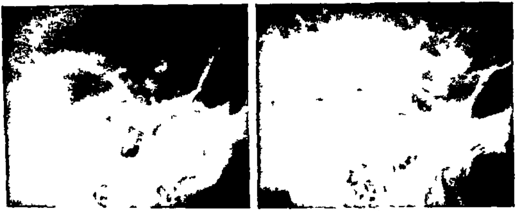
a b

Fig 14 Male aged 35 years (Primary subarachnoid haemorrhage 5 days prior to angiography) Carotid arteriograms a) Left Left posterior communicating artery outlined and aneurysm present at anterior origin of this vessel b) Right, with left carotid compression Good cross-flow via anterior communicating artery sac of aneurysm outlined by retrograde flow in left carotid siphon

artery It is accepted that carotid artery ligation may not be therapeutically successful in the presence of a large posterior communicating artery Thus the decision whether to ligate the carotid artery in the neck or to attack the aneurysm intracranially may be influenced by this further angiographic information

An example of the complete angiographic examination of an aneurysm arising at the origin of the posterior communicating artery from the internal carotid artery is illustrated in Figs 12 and 13 This case presented with a III nerve palsy but no history of subarachnoid haemorrhage Carotid angiography with carotid artery compression on the side of the aneurysm showed good cross flow via the anterior communicating artery (Fig 13a) but vertebral angiography with carotid artery compression showed no forward flow (Fig 13b) presumably due to occlusion or very small calibre of the posterior communicating artery on the side of the aneurysm Thus the carotid and vertebral arteriograms illustrated in Fig 13 showing the flow around the circle of Willis with left carotid artery compression indicated the actual blood flow which would be likely to exist in the immediate period following left carotid ligation

If the posterior communicating artery outlines at carotid angiography, in the presence of an aneurysm at its anterior origin it would appear likely from the basic information already gained by study of the preliminary series of cases that the blood flow in this vessel would be reversed following carotid artery ligation The forward contribution through the posterior communicating artery and the extent of filling of the sac of the aneurysm can only be assessed however by vertebral angiography with compression of the carotid artery



a b

Fig 15 Same case as in fig 14 a) Vertebral arteriogram on serial film changer with left carotid compression Late arterial phase showing faint contrast filling of aneurysm b) Post-operative vertebral arteriogram 6 weeks after left carotid ligation The calibre of the left posterior communicating artery is enlarged (cf fig 14a) and the aneurysm is densely filled with contrast medium



a b

Fig 16 Male aged 40 years (Subarachnoid haemorrhage 5 days prior to angiography a Right carotid arteriogram. Small aneurysms at anterior origin of right posterior communicating artery b) Indirect vertebral arteriogram with right carotid compression Flow reversed through posterior communicating artery with filling of aneurysm at anterior origin of this vessel large aneurysm demonstrated at termination of basilar artery

An example of such a case is illustrated in Figs 14 and 15 In this case, with recent subarachnoid haemorrhage the posterior communicating artery on the side of the aneurysm was of medium calibre (Fig 14a) and at carotid angiography with carotid artery compression the sac of the aneurysm was outlined by retrograde flow down the carotid siphon (Fig 14b) This finding indicated that the contribution of forward flow via the posterior communi

RÉSUMÉ

L'auteur examine et illustre par des exemples l'intérêt de l'etude angiographique de la circulation dans l'artere communicante antérieure par les tests de compression de la carotide. Il decrit une methode d'angiographie vertebrale permettant l'étude de la circulation dans les arteres communicantes posterieures par des epreuves de compression de la carotide et il examine et illustre par des exemples l'interêt de cet examen.

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ANOMALOUS DRAINAGE OF THE INTERNAL CAROTID ARTERIES VIA THE VEINS OF THE SCALP

by

V GVOZDANOVIC, P FRAK and I RAK

Reports on the diagnosis of occlusion of the veins and sinuses of the brain by means of serial cerebral angiography are scarce KRAYENBUHL (1955) GERLACH (1955) and HUHN (1957) and, further CHATTERJEE & CHIARI (1958) dealt with the subject, and it is mentioned briefly in recent monographs on cerebral angiography (BONNAL & LEGRE (1958), TONNIS & SCHIEFER (1959) DECKER (1960))

The present case was diagnosed by us five years ago Since then the condition has remained unchanged and the case is now published as a contribution to the literature in this interesting field

Case report

Boy aged 8 years of healthy parents he had had measles at the age of 3 months diphtheria at 18 months and pertussis when two and a half years old

Four years before admission to our hospital the child had had an acute illness with a temperature of 40 C, headache and cerebral vomiting and was treated at home for meningitis The condition cleared up after about ten days but the veins of the scalp then became dilated for some weeks

About 4 years after this the boy was admitted to hospital with a similar acute condition Kernig's and Lasègue's signs were positive papilledema was present Cerebrospinal fluid contained 570/3 mononuclears sugar and chlorides were within normal limits SF 1025 mm WBC 12 500 Haemoculture was negative The condition again resolved after ten days treatment with penicillin and streptomycin and he was discharged



Fig 1 a) and b) Dilated veins of the scalp more obvious on the left side c) Deep canals on the surface of the cranial bones visible and palpable through the skin d) On pressure upon the vein the distal part collapses while the proximal part becomes dilated

Some days later there was a short relapse with headache and vomiting together with slight paresis of the left facial nerve and as these signs and symptoms disappeared the veins of the scalp became dilated

He was then admitted to our hospital The veins of the scalp were pencil wide formed a caput medusae and were situated in deep canals in the cranial bones A small impression was palpable in the region of the right parietal emissary vein On pressure upon the vein the distal part collapsed while the proximal part became dilated indicating that the veins of the scalp had taken over the function of drainage of the endocranium (Fig 1)

Papilledema with + 3 prominence on the right and + 2 on the left side and some papillary haemorrhages were present The cerebrospinal fluid pressure was elevated to 370 mm measured in lateral decubitus position EEG was abnormal but without focal localisation All other routine examinations were normal



a b

Fig 2 a) Deep lacunar fossae situated on both sides of the sagittal suture b) Multiple canals — emissary veins connecting the granular foveoles with the surface of the cranium

Under treatment with Liquemin (Roche) and Nison (Lepetit) the veins changed in size sometimes being broad and sometimes rather small and practically collapsed when the head was in the same position This variation continued during the existence of the papilledema as well as after its disappearance and continues today four and a half years after the patient left hospital

The boy was last seen about six months ago He was physically and psychically normally developed and one of the best pupils in his class at school The veins of the scalp become *dilated only when the head is flexed The canals of the cranial bones were palpable* the changes in the craniograms were the same as five years previously Control cerebral angiography was refused by the parents

Discussion

Deep lacunar fossae situated on both sides of the sagittal suture were evident in the a p view and multiple canals connecting the granular foveolae *with the surface of the cranium were evident in the region of the sagittal* suture in the lateral and oblique views (Figs 2 and 3) These multiple parasagittal emissary veins, which are normally obliterated in the first year of life, were evidently dilated and represented the patent embryonal com*munications between the superficial veins of the brain* and the system of the veins of the scalp One of these emissary veins was shown tomographically and there were no roentgenologic signs of increased intracranial pressure

Serial angiography (Figs 4, 5 6) of the right and left internal carotid arteries was performed under general anaesthesia *The superficial veins of the* brain (Figs 4a, 5a 6a) were well developed The ascending veins emptied into broad lateral lacunae from which already in the early phase pencil



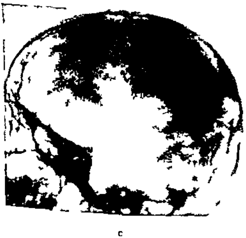
Fig 3 Oblique projections of the parasagittal region sho ing multiple emissary veins.



a



b



c

F g 4 Serial angiography of the left internal arot d artery venous phase The ascending eins empty into broad lacunae from wh h pencil wide and tortuous vein of the scalp a e being fill d early on The system of th central ve ns is dra ned through the t nto al plexuses (arrows) The super or and nferio agittal nuses and the straight and lateral s nuses ar not filled



a b

Fig 5 Serial angiography of the right internal carotid artery venous phase the scalp veins are not as numerous as on the left side

wide and tortuous veins of the scalp were filling through the multiple para sagittal emissary veins (Figs 4 and 5b) The superior and inferior sagittal sinuses as well as the straight and lateral sinuses were not filled with con trast medium, superposition of the veins of the scalp was not mistaken for these sinuses The system of the central veins of the brain was drained through the tentorial plexuses which in the lateral view had an appearance resembling tentorium (Fig 4, a and b), but in the a p views had the typical appearance of the tentorium (Fig 6a)

Conclusion

There was roentgenologic evidence of obstruction of the superior and in ferior sagittal sinuses as well as the straight and lateral sinuses with drainage of the superficial veins of the brain through multiple emissary veins into the system of the veins of the scalp The drainage of the central veins, which is effected by the tentorial plexuses, was of special interest The history and the clinical data suggest *recurrent thrombosis of the sinuses* at the beginning of the fourth year of life The roentgenologic findings indicate a gradual devel opment of the process beginning in the first year of the life or an anomaly in the development of the sinuses The manifestation of the clinical signs may be attributed to the superimposed infection The changes in the width of the veins of the scalp may have been due to a valve mechanism caused by a retracted thrombus

We have not been able to find a similar case in the literature



Fig 6 Angiography of the left internal carotid artery venous phase Some of the veins of the scalp on the right side are also filled The veins of the tentorium are just shown (arrows)

SUMMARY

A case of large tortuous veins of the scalp draining the endocranium in a child is reported At angiography of the right and left internal carotid arteries most of the medium emptied through multiple parasagittal emissary veins into the veins of the scalp and the system of deep veins was drained through the tentorial venous plexuses The roentgenologic findings suggested thrombosis early in life or an anomaly in the development of the sinuses as the cause

ZUSAMMENFASSUNG

Ein Fall mit grossen schlingrigen Venen des Skalpes welche das Endokranium eines Kindes drainerten wird berichtet. Bei der doppelseitigen Angiographie der Arteria carotis interna wurde der grösste Teil des Kontrastmittels durch multiple parasagittale kleine Venen in die Venen der Kopfschwarte und das System der tiefen Venen durch den venosen Plexus tentorius draniert Die rontgenologischen Befunde deuten darauf hin dass eine Thrombose in fruhem Alter oder eine Entwicklungsanomalie der Sinus die Ursache sind

RÉSUMÉ

Les auteurs présentent le cas d un enfant dont l encéphale se drainait par de grosses veines tortueuses du cuir chevelu Au cours de l angiographie carotidienne interne droite et gauche la majeure partie du contraste s evacuait par de nombreuses veines émissaires parasagittales dans les veines du cuir chevelu et le systeme veineux profond s évacuait par les plexus veineux tentoriels Ces anomalies radiologiques pourraient etre dues à une thrombose survenue tres tôt ou à une anomalie de développement des sinus

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ANGIOGRAPHIC AND HISTOLOGIC CHANGES IN INFUNDIBULAR WIDENING OF THE POSTERIOR COMMUNICATING ARTERY

by

OVE HASSLER and GEORG FREDRIK SALTZMAN

The proximal part of the posterior communicating artery is often funnel shaped at its origin from the carotid siphon and may vary considerably in size and outline (ref 4 Fig 1) In some cases in which the posterior communicating artery has not been filled, a broad based varying bulge in the wall of the carotid siphon may be evident at the site where the posterior communicating artery arises (ref 4, Fig 2)

A survey of a normal material of 1 020 angiographies (angiographies without evidence of other vascular changes) revealed bulging of the vessel wall at the typical site in 67 cases (SALTZMAN) Approximately the same incidence was established in a material comprising 223 cases of intracranial expansive processes and 118 cases of arterial aneurysm in the carotid region The figures correspond to ten per cent of the carotid angiographies in which the posterior cerebral artery was not demonstrated The appearance of the bulge corresponded in many cases with the funnel shaped proximal part of the posterior com

municating artery In two cases, bulging in the carotid siphon was visible on both sides As may be seen from Fig 1 the incidence of bulging increased with advancing age Angiography had in several cases been carried out on more than one occasion, filling of the posterior cerebral artery was obtained at one examination while at another bulging at the point of origin of the posterior communicating artery was evident The bulge corresponded with the infundibular part of the posterior communicating artery

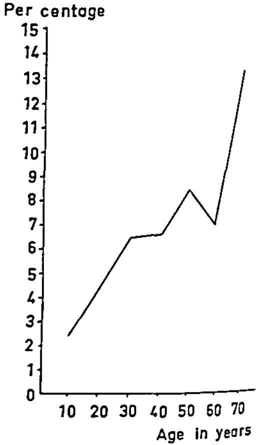


Fig 1 Diagram showing how the incidence of infundibular widening of the posterior cerebral artery increases with advancing age

In an analysis of 265 rapid serial angiographies of the carotid artery we noted that the posterior communicating and posterior cerebral arteries were sometimes filled in only one or a few views obtained in the arterial phase This finding made it possible in some cases to study at one and the same injection the infundibular part of the posterior communicating artery both when it alone was filled and when it was demonstrated together with other parts of the vessel These observations gave added support to the view that the above mentioned bulging in the carotid siphon is identical with an infundibular widening of the proximal part of the posterior communicating artery Compression of the vertebral artery may be used to ascertain whether a bulging in the carotid siphon corresponds with an infundibular widening of the posterior communicating artery (SALTZMAN ref 3, Fig 1)

A bulge in the carotid siphon could be studied in many of the rapid serial angiographies without the rest of the posterior communicating artery being visible in any of the films In the majority of cases the bulge had exactly the same appearance in all the views in which it could be demonstrated One case alone formed an exception to this rule (Fig 2) in that the bulge varied considerably in appearance in the different views

In order to ascertain the relation between an infundibular widening of the

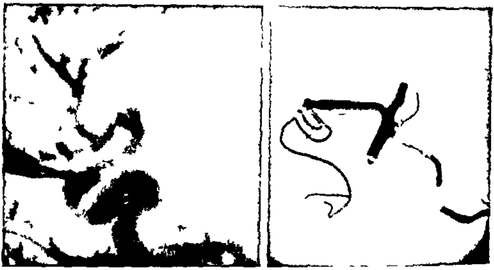


Fig 2 Varying appearance of infundibular widening of the posterior communicating artery in films from rapid serial angiography

posterior communicating artery and the clinical signs the hospital records of all cases displaying this angiographic feature were examined This investigation revealed that 16 cases had had subarachnoid haemorrhage, while the other clinical signs varied considerably Of the 16 cases with subarachnoid haemorrhage 6 had an aneurysm in the carotid area of the opposite side and in 3 of these at the origin of the posterior communicating artery from the carotid siphon Two of the 16 cases had a systolic blood pressure of between 250 and 300 mm Hg An explanation of the haemorrhage was thus at hand in these 8 cases In the other 8 cases no explanation could be found, this figure is fairly high

The proximal part of the posterior communicating artery is not the only site within the carotid region where infundibular widening may occur The proximal part of the anterior choroidal artery also occasionally shows such an anomaly although it is not common In the few cases in which we have seen this change widening was present both in the proximal parts of the anterior choroidal and posterior communicating arteries (Fig 3)

We have not carried out any systematic examinations of other intracranial vessels with a view to finding further examples but we have encountered one case in which the proximal portion of the ophthalmic artery showed this feature (Fig 4) In another case there was evidence of a bulging of the vessel wall in the carotid siphon proximal to the posterior communicating artery, which [illegible] an infundibular widening (Fig 5) A very narrow artery ran downwards from this bulge which was probably identical with an infundibular widening of [illegible] of the small arteries usually not visible at angiography running to the [illegible] ysis the cavernous sinus wall, or to some of the cranial nerves It is [illegible] not unlikely that funnel shaped widening of the proximal part of other vascular branches may occur as well



a b

Fig 3 Infundibular widening of both the anterior choroidal and posterior communicating arteries a) Carotid angiography b) Autopsy specimen from another case

We have investigated autopsy material from several cases in which the proximal part of this artery showed infundibular widening with the object of investigating the histologic aspects of a possible connection between infundibular widening of the posterior communicating artery and subarachnoid haemorrhage A preliminary report of our histologic findings in 7 cases has already been published This material has now been increased to 21 cases of infundibular widening of the posterior communicating artery subjected to histologic examination Defects in the muscular media were observed in all the cases examined The defect was very large (greatest diameter over 1 mm) in 14 cases and in 6 of these the elastic lamina was also absent in the wall, which was composed of collagenous connective tissue as in an aneurysm (Fig 6) In these 6 cases the edge of the media was rounded off and that of the elastic lamina was clear cut, both being embedded in collagenous tissue The histologic appearances were thus identical with those of a minute aneurysm (HASSLER) Large media defects on the intradural part of the internal carotid seem to be very uncommon in a normal material (STEHBENS HASSLER) In the remaining 7 cases of infundibular widening the media defect was considerably smaller (greatest diameter less than 1 mm) Even these small defects seem to be rare in this part of the artery in a normal material (HASSLER) The defects were in all cases situated in the distal carina between the internal carotid artery and the posterior communicating artery and intima cushions were often seen in the proximal part of the carina opposite to the defects



Fig 4 a) Infundibular widening of the ophthalmic artery b) The change is better shown with the subtraction method

Of the 21 cases in which we were able to carry out a histologic examination there were 4 in which the infundibular widening of the posterior communicating artery had been demonstrated angiographically in vivo Large media defects were present in 3 of these cases and a small defect in the fourth

The clinical significance of infundibular widening of the posterior communicating artery is obviously of interest As we have shown this change is not uncommonly encountered at carotid angiography In many instances only the widened infundibular part of this artery becomes filled with contrast medium while its other parts are not outlined it may then be difficult to distinguish the changes from arterial aneurysms situated at the site where the posterior communicating artery springs from the carotid siphon The similarity between aneurysm and infundibular widening of the posterior communicating artery is also evident from the fact that infundibular widening was found to be common in patients surviving subarachnoid haemorrhage As was the case with media defects and aneurysms (STEHBENS HASSLER) the frequency of infundibular widening increased with advancing age

The histologic findings suggest that infundibular widening is an early stage of aneurysm formation at the point of bifurcation of the internal carotid artery and the posterior communicating artery As the histologic appearances correspond in every respect to those of a minute aneurysm and as HASSLER has described cases in which such minute aneurysms have ruptured the risk should be borne in mind in cases in which infundibular widening of the posterior



Fig 5



Fig 6

Fig 5 Further bulging of th siphon wall proximal to an *infundibular widening a narrow artery runs downwards* from the bulge

Fig 6 Histologic specimen from a large media defect in infundibular widening of th posterior communicating artery The vessel wall consists of collagenous connective tissue only

communicating artery or other branches of the internal carotid artery has been demonstrated at carotid angiography Although minute aneurysms appear to rupture less frequently than sacculated aneurysms the radiologist should nevertheless consider it his duty not to disregard the vascular changes discussed in this paper

SUMMARY

The angiographic appearance of widening of the proximal part of the posterior communicating artery is described in detail Similar changes in other vessels related to the internal carotid are also dealt with The histologic findings in several cases of infundibular widening are presented The relation between these changes and clinical symptoms especially regarding subarachnoid haemorrhages is discussed.

ZUSAMMENFASSUNG

Es wird das angiografische Aussehen der Erweiterung des proximalen Teiles der Art communicans post im Detail beschrieben und ähnliche Veränderungen anderer Karotisäste mitgeteilt Es werden die histologischen Befunde bei einigen Fällen von infundibulärer Erweiterung gezeigt, und die Beziehung zwischen diesen und den klinischen Befunden, im Besonderen mit Hinsicht auf subarachnoideale Blutungen wird besprochen.

RÉSUMÉ

Les auteurs décrivent en détail l aspect angiographique de la dilatation de la partie proximale de l artere communicante posterieure Ils décrivent aussi des modifications semblables sur d autres vaisseaux en relation avec la carotide interne Ils présentent les résultats de l examen histologique de plusieurs cas de dilatation infundibulaire Ils examinent les relations existant entre ces modifications et les signes cliniques, en particulier en ce qui concerne les hemorragies sous arachnoidiennes

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RELATION OF THE INTERNAL CAROTID SIPHON TO THE CAROTID SULCUS

by

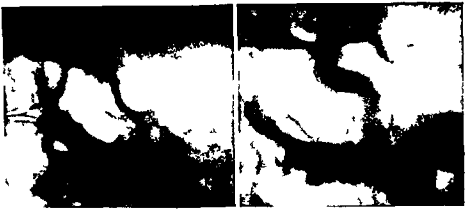
PIOTR KOZLOWSKI

The internal carotid sulcus is one of a number of parts of the skull of which our knowledge of the radiologic anatomy remains incomplete The demonstration of the course of the sulcus may often be of importance in the evaluation of intracranial lesions

The internal carotid sulcus is visible in lateral views of the skull superimposed on the sphenoid bone or on the sphenoidal sinus in the form of a linear S (Fig 1a) The roentgenologic anatomy of the carotid sulcus was discussed by ENGELS who stated that the internal carotid sulcus could be seen in 64 % of lateral roentgenograms of the skull, he believed that its demonstration was uninfluenced by age or sex

The purpose of this work was to compare the ordinary roentgenologic appearances of the internal carotid sulcus with anatomical data and arterial filling obtained by angiography

A part of the whole of the course of the internal carotid sulcus was evident in 56 % of 200 living subjects, aged 25 to 78 years The posterior part of the sulcus, the region where the internal carotid artery emerges from the carotid canal of the temporal bone, was best seen in 50 dried skulls The anterior part of sulcus is marked by a bony ridge which runs down from the base of the anterior clinoid process along the lateral surface of the sphenoid bone It is seen in the roentgenograms in the shape of a triangle with its base directed upwards



a b

Fig 1 a) The carotid sulcus b) Arteriogram in a case of a 56-year-old male with atheromatosis The posterior part of the internal carotid siphon is superimposed on the outline of the carotid sulcus

The middle part of sulcus is the least constant It may sometimes be visible above the outline of the floor of the sella turcica If embedded in the sphenoid bone it must be differentiated from the trabeculae and the bony septa of the sphenoidal sinus The middle and posterior parts of the carotid sulcus are more easy to determine if they constitute a prolongation of the anterior part, the course of which is more or less constant The carotid sulcus may sometimes at the level of the clinoid process, be transformed into an arterial foramen by ligamentous calcification The radiologic anatomy of this foramen has been discussed by ETTER inter alios The foramen was present in 6 of the 50 dried skulls in this material

The relation of the internal carotid siphon to the carotid sulcus was determined in angiograms in 100 living subjects In 22 the siphon was straight in 48 it was intermediate and in 30 it was sigmoidal in shape According to MONIZ (1934) ECKER (1951) PLATZER (1957), BONNAL & LEGRE (1958) the shape of the siphon has no pathologic significance Some authors (WICKBOM (1948), BENASSI et coll (1957), inter alios) believe that in cases of arteriosclerosis the internal carotid siphon may be lengthened curved and irregular in outline

The course of the anterior part of the internal carotid siphon in the material was always the same as the course of the carotid sulcus on the sphenoid bone The posterior part of the internal carotid siphon was superimposed on the outline of the carotid sulcus in 2 cases of atheromatosis however (Figs 1b and 2) The outline of the carotid sulcus suggested that the displacement of the posterior part of the siphon was secondary and had developed as the result of atheromatosis



Fig 2 Arteriogram in a case of a 62 year-old male with atheromatosis showing the same phenomenon as in fig 1b

The course of the internal carotid artery inside the cavernous sinus was verified post mortem in 20 cases The initial part of the internal carotid siphon in the region where it emerges from the carotid canal of the temporal bone and the terminal part at the level of the anterior clinoid processes are fixed and cannot be displaced The middle part of the siphon inside the cavernous sinus may, on the other hand become elongated and curved The connective tissue septa inside the cavernous sinus are thin and cannot prevent displacement of the vessel It would appear that differences in the courses of the internal carotid siphon and carotid sulcus may be of diagnostic value in atheromatosis although the possibility of other abnormalities that may *cause displacement of the carotid siphon must be borne in mind* in a consideration of the differential diagnosis In any case it is always advisable to perform bilateral angiography to determine the form of both carotid siphons.

SUMMARY

The roentgenologic anatomy of the carotid sulcus and its relation to the carotid siphon, based on a material of 200 living subjects and 50 dried skulls is described.

ZUSAMMENFASSUNG

Die Rontgenanatomie des Sulcus caroticus und seine Beziehungen zum Carotissiphon wird auf Grund eines Materiales von 200 lebenden Personen und 50 getrockneten Schadeln beschrieben.

RÉSUMÉ

L auteur decrit, en se basant sur une série de 200 sujets vivants et de 50 cranes secs l anatomie radiologique de la gouttiere carotidienne et ses rapports avec le siphon carotidien.

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CHANGES IN LOCAL CIRCULATION TIME IN FRONTAL AND PARIETAL TUMORS STUDIED BY RAPID SERIAL ANGIOGRAPHY

by

NORMAN E LEEDS and JUAN M TAVERAS

The angiographic demonstration of local slowing of circulation is of value in the diagnosis of brain tumors Although increased speed of circulation is well known, the local slowing of circulation has received little attention It is the purpose of this paper to analyze these dynamic changes and to evaluate their relative incidence Temporal tumors are excluded as they only rarely produce local circulatory changes other than the increased speed of circulation secondary to the occurrence of abnormal vessels

MONIZ in 1927 was the first to study the cerebral circulation utilizing carotid angiography Since that time many observers have studied cerebral circulation by means of rapid serial angiography CURTIS (1951), SCHURR & WICKBOM (1952), and GANSHIRT & SCHIEFER (1954) defined the circulation time as being from the end of the carotid injection to the time when venous emptying is complete The normal variations range from 6 to 12 seconds Two very important variables that have been pointed out by some authors (4, 5, 10 12) which may influence these results are the amount of contrast substance injected and the injection time One cannot standardize the injection time unless a pressure injector is utilized

GREITZ (4, 5) feels that because of the variations in venous filling the lack of identification of the internal jugular vein the difficulty in determining the completion of the venous phase (to complete venous emptying), and the dif

ference in circulation time which occurs with the varying amounts of contrast and injection times used, the calculation of the circulation time should be from filling of the carotid siphon to filling of the parietal veins He considers the parietal veins to represent the average of the venous phase He measures the circulation time from the beginning or maximal contrast of the carotid siphon to the beginning or maximal contrast in the parietal veins This we have called the arteriovenous circulation time but only the maximal concentration in both the siphon and the parietal veins was used because the interval from beginning to maximal filling of the carotid siphon was from 0 25 to 0 75 sec, while this may amount to between 0 5 and 1 5 sec in the parietal veins According to GREITZ (5) the circulation time varied between 2 7 and 5 5 sec in 32 cases, with a mean value of 4 13 sec, and a standard deviation of plus or minus 0 74 sec

Definitions The observations on the circulation time utilized in this paper are as follows

I *Arterial circulation time*

A — general consists of arterial filling and emptying phases, the time ends as the terminal arterial twigs begin to disappear

B — local refers to the arterial filling and the arterial emptying phases in the territories of the middle cerebral artery (insular, frontal, parietal and occipital) and the anterior cerebral artery (frontal and parietal)

II *Arteriovenous circulation time*

A — general the time from maximal concentration of the contrast substance in the carotid siphon to maximal concentration in the parietal veins

B — local the time from maximal filling of the carotid siphon to maximal filling in the local veins (frontal, sylvian, parietal, or occipital)

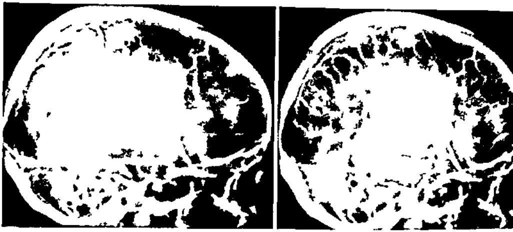
III *Intermediate circulation time*

A — general from arterial emtying to the beginning of venous filling

B — local from arterial *emptying to venous filling in the local areas*

Rapid serial angiography has been performed at the Neurological Institute since 1953 in all cases Except in special situations the first six films are made at 0 5 sec intervals starting with the injection, and the next four films are made at 1 sec intervals If there is evidence of increased intracranial pressure two additional films at 1 sec intervals are made

Since 1957 a pressure injector has been used which is equipped with a micro switch cut off if the pressure exceeds 50 pounds per square inch with an injection time varying from 1 to 1 25 sec The contrast agent presently used is Renografin 60 %, but previously Hypaque 50 % was used



a b

Fig 1 Normal veins a) *Early venous phase* filling of all superficial veins (frontal sylvian parietal and occipital) the inferior longitudinal sinus and the deep veins b) One second later filling is more intense the orderly and regular appearance of the veins should be observed The superficial and deep veins have filled simultaneously (cf GREITZ and MONIZ)

One hundred normal rapid serial angiographies were analyzed to evaluate the local and general circulation times in the arterial, arteriovenous, and intermediate phases

Arterial filling is dependent on the flow in centimeters per second from the carotid siphon In the normal subject, the filling of the frontal branches of the anterior cerebral and the insular branches of the middle cerebral arteries are the first to be seen to fill The normal local arterial circulation time of the anterior cerebral arteries varies from 0 5 to 2 5 sec and the same applies to the opercular branches of the middle cerebral artery The insular portion of the branches of the middle cerebral artery represent the segments within the sylvian fissure The frontal opercular, parietal opercular and occipital arteries are the branches in the specific anatomic area after the arteries have left the sylvian fissure and are on the surface Because of the difference in distance from the carotid siphon the frontal and parietal opercular branches fill after the insular branches, although occasionally there is simultaneous filling observed of all the opercular and insular branches The frontal and parietal opercular branches usually fill at the same time varying from 0 5 to 2 5 sec The occipital branches of the middle cerebral artery usually fill 0 25 or 0 5 sec after the filling of the parietal opercular branches, but occasionally they fill at the same time The distal branches of the frontal and parietal opercular arteries fill 0 25 to 0 5 sec after *filling of the proximal portions* *The parietal* branches of the anterior cerebral artery usually fill approximately 0 5 sec after the frontal branches Arterial emptying follows a similar sequence to the arterial filling

Table 1

Types of tumor and disease in the 125 cases reviewed

Glioblastoma	38
Astrocytoma	18
Mixed oligodendroglioma astrocytoma	1
Metastatic	23
Meningioma	33
Reticulum cell sarcoma	4
Arteriovenous malformation with hematoma	5
Encephalomalacia	1
Abscess	2
Total	125

The *general arterial circulation* time varies from 1.0 to 2.5 sec with a mean value of 1.8 sec and a standard deviation of plus or minus 0.54 sec.

The *intermediate phase* varies from 0.25 to 1.0 sec.

The *venous phase* usually begins with filling of the frontal or sylvian veins either together or one before the other (Fig. 1). The parietal and occipital veins then fill in sequence. At times, though, all veins may fill simultaneously. The parietal and occipital veins never fill before the frontal or sylvian veins and if they do one should suspect that this is abnormal. Local venous circulation time varies from 2 to 6 sec.

The general *arteriovenous circulation* time varies from 2.5 to 6 sec. The mean is 4.37 sec plus or minus a standard deviation of 0.83 sec.

Material. There have been approximately 325 cases of frontal and parietal tumors studied since 1953 at the Neurological Institute by means of rapid serial angiography. In this study 125 cases with frontal and parietal tumors were chosen at random and include 137 abnormal arteriograms and 15 normals. Of the 137 abnormal arteriograms recorded, 4 were of the second side and 8 were postoperative or follow up examinations. The histologic diagnosis is indicated in Table 1.

Angiographic findings

No effort will be made to describe any local displacements or shift of vessels as an aid in the diagnosis of these lesions. The discussion will be limited to the local circulatory changes observed (Table 2) and their value as an aid in localization and sometimes in the histologic diagnosis of frontal and parietal tumors.

Table 2

Local circulatory changes

Circulatory changes	Cases	Percentage of total
Delayed appearance of a local artery	27	20
Delayed appearance of local veins without tumor circulation	46	34
Delayed appearance of local veins with tumor circulation	15	11
Lengthening of intermediate phase	16	13
Tumor circulation with early veins	32	23
Early appearance of a local vein	15	11
More than one of above	41	30
No change in local circulation	12	9

I Lengthening of circulation time

A — Local arterial circulation time In 27 of the abnormal arteriograms there was evidence of *delayed appearance* of one or more arteries (Fig 2) These arteries had a normal configuration in all except one case of encephalomalacia The delayed appearing arteries usually empty after the remainder of the local arteries These changes are not observed in the normal subject The consideration that an artery showed delayed filling was not dependent on the size of the artery but rather on whether the artery was filled or not A larger artery is denser than a smaller one on the films but that does not mean that it is better filled Without the use of serial angiography the identification of the delayed appearance would be impossible Care should be taken not to confuse an external carotid artery branch with delayed filling of a branch of the internal carotid artery This is easily avoided with the use of serial roentgenograms

The reason for delayed local appearance of one or more arteries is not well known KRAYENBUHL & RICHTER (1952) and WICKBOM (1953) commented upon the delayed appearance of tumor arteries in a glioma in comparison to the normal brain, which was thought to be due to constriction of blood vessels or perifocal edema GREITZ (1956) (5), and TONNIS & SCHIEFER (1959) express the opinion that changes in local arterial circulation are rare The reason for the delayed appearance of one or more arteries may be secondary to local pressure caused by the mass lesion and/or the associated edema The mass may be adherent or juxtaposed to the artery There may be local anoxia as in the cases of encephalomalacia Arterial circulation slowing may be an aid in differential diagnosis as these changes occur primarily in intra axial tumors, gliomas and metastases (22 cases) and rarely in extra axial tumors such as meningiomas (5 cases)

Delayed emptying of local arteries is also significant and may be explained by similar reasons as those noted above



a b

Fig 2 Case of metastases D layed fill ng of a local artery a) Good filling of insular branches and of frontal and parietal opercular branches of middle cerebral artery with delayed filling of a single frontal opercular artery (arrow) b) 0 5 sec later in the sequence good fill ng of the slowfilling artery (arrow)

B — Delayed appearance of local veins without tumor circulation There were 46 cases with evidence of local venous slowing without tumor circulation This is a frequent finding as evidenced by its occurrence in approximately one third of the cases in this series Ten of the cases were meningiomas thirty four gliomas or metastases one hematoma and one brain abscess The importance of these local changes as an aid in localization and diagnosis of brain tumors has been reported by GREITZ (1956) (4 5), GVOZDANOVIC (1956), and TONNIS & SCHIEFER (1959)

The sequence of superficial venous filling is regular and orderly and any disturbance of this pattern should be suspect There may be local slowing of a single vein or slowing of all the veins in a local area giving an appearance of avascularity If one looks for the orderly venous filling and studies the serial roentgenograms, the delayed appearance of a single vein will become obvious (Fig 3) Without the aid of serial angiography however one may easily over look a delayed appearing of a vein as it may be present on only one or two frames in the serial

The venous walls are thin and so veins are more subject to compression Local venous changes may be caused by compression secondary to the mass itself or to edema Other causes of deficiency of the veins may be thrombosis or secondary involvement of the veins by tumor In a post operative case local venous changes in the operative area may be secondary to previous surgery

Deviations of the venous flow pattern may be observed secondary to ob struction of local veins or to involvement of the superior sagittal sinus Reversal of venous flow with delayed appearance of veins was observed in ten cases Seven were meningiomas and three were gliomas or metastases



a b

Fig 3 Case of astrocytoma Delayed filling of local veins a) Intermediate phase paucity of vessels clearly defining the limits of the lesion (arrows) b) Early venous phase paucity of veins in the posterior frontal region with poor filling of a single vein (arrow) c) Venous phase one sec later the poorly filled vein (arrow) observed in (b) is now better filled *there is now delayed filling* (two arrows) of a vein not seen on the previous roentgenogram



c

When there is compression of veins secondary to the mass and/or to secondary edema the marginal veins that fill earlier will clearly define the limits of the mass

The delay in venous emptying will be of no value in attempting to decide whether a mass is intra axial or extra axial, as either lesion may cause venous compression with the secondary local changes However if there is evidence of obstruction of the superior sagittal sinus with delayed venous emptying or reversal of flow, a diagnosis of meningioma is justifiable

C — Delayed appearance of local veins with tumor circulation This delayed appearance of local veins with areas of tumor circulation occurred in 15 cases of which 12 were meningiomas and only 3 were gliomas MONIZ (1927), and MONIZ, PINTO & LIMA (1929) were first to describe these local circulatory changes in meningioma, which they ascribed to the slower circulation in the meningioma than in the rest of the brain

These local changes do not require serial angiography to be performed Almost all of the patients with a tumor circulation with delayed venous emptying had meningiomas

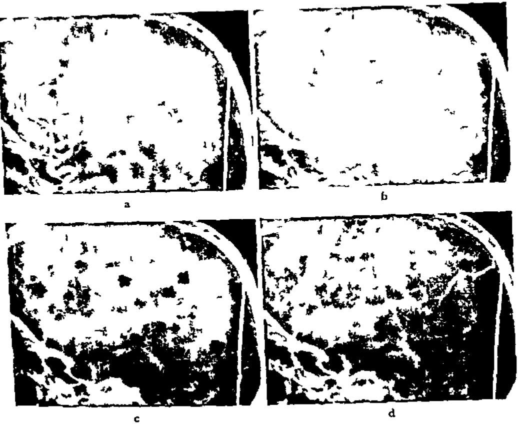


Fig 4 Case of glioblastoma Early filling of a vein a) Arterial phase normal arterial filling with no disturbance of the normal vascular pattern b) Late arterial phase 0 5 sec later in the sequence no abnormality c) Intermediate phase 0 5 sec later an early filling parietal vein is revealed (two arrows) The only other vessels opacified are branches of the external carotid artery (arrows) d) Early venous phase 0 5 sec later there is beginning filling of both the deep and superficial veins The parietal vein which filled early now shows the most opacification No alteration is observed in the anatomical configuration of the vessels The only abnormality is that of a vein filling early out of normal sequence which usually signifies the presence of a malignant lesion

D — Lengthening of the intermediate phase The lengthening of the intermediate or capillary phase occurred in 16 cases These changes were observed in 12 intra axial tumors and in 4 meningiomas When local capillary slowing occurs especially at the margins of the tumor the exact localization and size of the tumor may be clearly seen

II *Shortening of circulation time*

A — Tumor circulation with early veins This is well known and was first observed by Tonnis (1937) These observations may often be made without the aid of serial roentgenograms There were 32 cases of tumor hypervascularity and increased speed of circulation as demonstrated by the early appearance of

draining veins. These findings were observed mainly in glioblastomas and metastases, but there was one case with a reticulum cell sarcoma of the frontal lobe, one with a partially thrombosed arteriovenous malformation, and one case of meningioma. The coincidence of tumor hypervascularity with increased speed of circulation means almost invariably that the lesion is malignant and is probably a glioblastoma multiforme or metastases.

B. — Early appearance of a local vein. A less well known phenomenon is the appearance of an early vein (2, 12, 14) signifying an increased speed of local circulation without evidence of tumor circulation. This finding may be the only abnormality demonstrated, and without the benefit of serial angiography may easily be missed since it may be observed on only one film in the series and the appropriate film may not be included (Fig. 4). This finding was present in 15 cases of which 3 were glioblastomas, 2 astrocytomas, 4 metastases, 2 meningiomas, and 1 hematoma. In our series, this finding is suggestive of a malignant lesion. The only benign lesion one might suspect is a minute or a thrombosed arteriovenous malformation in which an early draining vein persists.

III. *General circulatory changes*

The slowing of the circulation throughout the brain is not uncommon with mass lesions within the brain, including all phases: arterial, intermediate, and venous. This incidence will increase when there is evidence of increased intracranial pressure.

There were 36 cases with evidence of slowing of the general arteriovenous circulation time, greater than 6.0 sec. These include 13 glioblastomas, 11 metastases, 7 meningiomas, 3 astrocytomas, 1 reticulum cell sarcoma, and 1 case of cerebrovascular disease and encephalomalacia.

Out of a total of 51 cases there were 17 (33 %) with clinical evidence of increased intracranial pressure with lengthening of the arteriovenous circulation time, while 34 cases showed no lengthening. The findings in this series were similar to those reported by GREITZ (5).

There were only 11 cases with evidence of generalized slowing in the arterial phase. All of these also had evidence of increase in arteriovenous circulation time except one case of a large frontal lobe abscess.

The changes in the general intermediate phase time are not different from those of the general arteriovenous circulation time because they are affected in a similar manner.

SUMMARY

Local circulatory changes such as delayed filling of one or more arteries or veins or early filling of one vein and tumor circulation with early or delayed appearance of draining veins occur frequently in frontal and parietal tumors. The delayed appearance of one or two

arteries usually occurs in intracerebral and less frequently in extracerebral tumors The delayed appearance of local veins without tumor circulation is of value in exact localization of tumors but is of no value in differentiating intracerebral from extracerebral lesions The early appearance of a vein when it occurs with or without tumor circulation is suggestive of a malignant intracerebral lesion

ZUSAMMENFASSUNG

Lokale zirkulatorische Veranderungen wie z B verlangsamte Fullung einer oder mehrerer Arterien oder Venen oder fruhzeitige Fullung einer Vene wie auch Tumorzirkulation mit fruhzeitiger oder verzogerter Darstellung der ableitenden Venen kommen haufig bei Frontal und Parietallappentumoren vor Die verzogerte Fullung einer oder zweier Arterien geschieht gewohnlich bei intracerebralen Tumoren weniger haufig bei den extracerebralen Die Verzogerung der Darstellung von lokalen Venen ohne vorhandene Tumorzirkulation ist fur die exakte Lokalisation von Tumoren wertvoll jedoch ohne Bedeutung bei der Differenzierung intracerebraler von extracerebralen Veranderungen Die vorzeitige Fullung einer Vene lasst sowohl mit als auch ohne Tumorzirkulation auf einen malignen Prozess schliessen

RÉSUMÉ

Les modifications circulatoires locales telles que l opacification retardée d une ou plusieurs artères ou veines ou l opacification précoce d une veine ou une circulation tumorale avec apparition précoce ou retardée de veines efferentes se produisent fréquemment dans les tumeurs frontales et pariétales L apparition retardée d une ou de deux artères se produit habituellement dans des tumeurs intracérébrales et moins souvent dans des tumeurs extra cérebrales L apparition retardée de veines locales sans circulation tumorale est utile pour localiser exactement les tumeurs mais n a pas de valeur pour distinguer les lésions intra cérébrales des lesions extracérébrales L apparition précoce d une veine isolée ou accompagnée d une circulation tumorale doit faire penser à une lésion intracérébrale maligne

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SERVICE DE L ELECTRO-RADIOLOGIE, (DIRECTEUR PROF J LEFEBVRE), HOPITAL DES ENFANTS MALADES PARIS FRANCE

ETUDE RADIOLOGIQUE DES GLIOMES INFILTRANTS DU TRONC CEREBRAL

par

J LEFEBVRE C FAURE et G SALAMON

Il peut paraitre vain et sans interet de reprendre l etude radiologique des tumeurs du tronc cerebral En effet leur sémeiologie a eté parfaitement decrite par de nombreux auteurs en particulier lors d un precedent Symposium Neuro Radiologicum par SUTTON (1953) Tous les traites classiques de neuro radiologie leur consacrent maintenant un chapitre important

Notre experience dans un hopital pediatrique comportant un large recrute ment de neurologie nous a montre que les problemes ne sont pas toujours aussi simples qu il apparait et que dans quelques cas la difficulte de l examen et de l interpretation neuroradiologiques rend circonspect dans l etablissement d un diagnostic dont on sait qu il comporte un pronostic fatal quoi qu on fasse Il importe donc de s entourer toujours d un maximum de precautions avant d affirmer une tumeur du tronc cérebral et de rechercher tous les signes qui permettront d etayer l hypothese envisagee ou au contraire de l infirmer C est ce que nous avons tente de faire en reprenant l etude detaillee de nos observa tions

Notre materiel comporte 51 cas dont 7 ont ete l objet d une verification post mortem 4 d une verification operatoire Pour tous les autres nous avons exige comme critere de certitude une semeiologie franche dont nous verrons plus

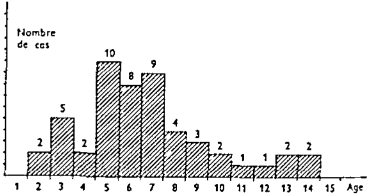


Fig 1 Répartition des cas en fonction de l age

loin les caracteristiques, des signes radiologiques nets et surtout une evolution progressivement fatale quelquefois freinee temporairement par la radiotherapie Ceci nous a donc amenes a éliminer du cadre de notre etude 2 patients encore vivants à ce jour, certainement atteints de gliome infiltrant du tronc cerebral mais améliores par radiotherapie, l un avec une survie de 4 ans et demi l autre avec une survie de 1 an et demi, et deux sujets perdus de vue

Anatomie pathologique L anatomie pathologique nous precise le caractere macroscopique et histologique de cette lesion et permet ainsi de mieux comprendre l evolution clinique et surtout la symptomatologie radiologique Nous résumerons l etude tres detaillee qu en font dans leur livre GUILLAIN et coll (1945)

La tumeur siege dans le tronc cerebral, partie du nevraxe comprise entre l hypothalamus et le collet du bulbe toutefois elle peut envoyer des prolongements vers les noyaux gris du mesencephale ou vers la moelle cervicale haute À l inverse les propagations vers le tronc cerebral de gliomes a point de depart hemisphérique ou mesencephalique doivent etre elimines du cadre de notre etude

Les tumeurs que nous envisageons sont des gliomes ce qui permet d exclure les tubercules, les metastases, les pinealomes les tumeurs vasculaires en particulier les hemangioblastomes

Enfin il s agit de tumeurs infiltrées ou infiltrantes, sans delimitation nette detruisant progressivement les centres nerveux, avec une extension importante interessant rapidement deux segments consecutifs du tronc cerebral Sur le plan morphologique GUILLAIN et coll précisent que le volume du tronc cerebral est augmente en masse, atteignant le double ou le triple de la normale la forme peut rester reconnaissable plus souvent les sillons se comblent ou disparaissent. La tumeur est elle molle, des phénomenes oedemateux s associent ils a l infiltration, les vaisseaux se creusent a la face anterieure du bulbe et du pont de profondes gouttieres et sont parfois recouverts par des bourgeons

hernies qui se rabattent sur eux Ce caractere infiltré en masse du tronc cerebral fait exclure de notre étude les tumeurs végétantes du plancher du 4e ventricule proliferant dans la lumière de cette cavite La consistance des gliomes infiltrants du tronc cérebral est variable suivant le siege et le type de l infiltration les foyers de necrose l oedeme et les hemorragies secondaires certaines sont d une durete quasi cartilagineuse L'envahissement dans le plan transversal est variable, il est rare que le tronc cerebral soit completement interessé bien souvent la tumeur est asymétrique, developpee soit en avant dans le pied soit en arriere dans la calotte soit d un coté Dans le sens axial, il est frequent que la gliomatose s etende du diencéphale au bulbe, mais la localisation pontine reste la plus importante, les formes hautes a envahissement pedonculaire semblent plus habituelles que les basses

Du point de vue histologique il s agit soit d astrocytomes, soit de spongioblastomes polaires, soit de glioblastomes Selon ARSENI et GOLDENBERG (1958), les spongioblastomes polaires seraient plus fréquents au dessous de 30 ans Sur 6 cas verifiés nous avons enregistre 4 astrocytomes ou spongioblastomes polaires et 2 glioblastomes

Circonstances etiologiques Tous les auteurs s accordent pour considerer qu il n y a pas d incidence de sexe, effectivement nous avons noté dans notre materiel 26 garçons et 25 filles

L age auquel survient la tumeur apparait sur notre tableau (Fig 1) Le pic aux alentours de 6 ans est retrouvé dans toutes les statistiques en particulier dans celle de BRAY CARTER et TAVERAS (1958) et dans celle de INGRAHAM et MATSON (1954)

La frequence de la localisation au tronc cerebral par rapport aux autres tumeurs cerebrales est tres particuliere a l enfant Notre mode de recrutement ne nous permet pas d etablir la proportion exacte pour la totalite des tumeurs du tronc que nous avons étudiees Dans une précedente statistique FAURE et coll (1959) nous avions note un pourcentage de 13 sur 128 soit 9 8 % de tumeurs du tronc La litterature nous rapporte des chiffres identiques chez l enfant BAILEY BUCHANAN et BUCY (1939) trouvent 12 tumeurs du tronc sur 100 cas de tumeurs cerebrales verifiees a l autopsie WALKER et HOPPLE (1959) trouvent le meme nombre de 12 % dans les verifications anatomiques ou operatoires INGRAHAM et MATSON (1954) notent 30 cas sur 313 tumeurs cerebrales chez l enfant ROCHE (1954) 11 cas sur 93 GROS et coll (1957) 7 cas sur 64 Chez l adulte par contre la frequence est moindre GUILLAIN et coll (1945) sur 250 cas reunis sans tenir compte de l age trouvent seulement 12 tumeurs du tronc cerebral soit 5 % BUCKLEY (1930) dans une statistique trouve 25 gliomes du pont sur un total de 732 gliomes intra craniens

Parmi les facteurs favorisants discutes dans la litterature on a insiste surtout sur le traumatisme ou sur les antecedents proches de maladie infectieuse, l un de nos patients a vu sa tumeur se manifester quelques semaines apres un

traumatisme cranien, un autre quelques semaines après une coqueluche Plus intéressant nous paraît le lien qui existe entre ces gliomes et la neurofibromatose déjà souligné dans un nombre de communications Deux de nos malades étaient porteurs de stigmates de maladie de Recklinghausen fibreuse

Étude clinique La symptomatologie clinique des tumeurs infiltrantes du tronc cérébral, telle qu elle nous est apparue, sera résumée brièvement, notre propos n est pas d en donner ici une étude statistique détaillée, disons toutefois que nous avons retrouvé des éléments symptomatiques très voisins de ceux publiés par BRAY et coll (1958) et INGRAHAM et MATSON (1954) la maladie a une installation habituellement assez rapide, en quelques semaines s institue un tableau clinique où les troubles de la marche, les troubles de la parole, la somnolence et le changement de caractère, quelquefois des céphalées ou un strabisme attirent l attention des parents Les signes d hypertension intra cranienne manquent souvent et les fonds d yeux sont habituellement normaux L examen neurologique, dans les formes habituelles, révèle l association d un syndrome pyramidal uni ou bilatéral, d un syndrome cérebelleux statique et cinétique et d une atteinte uni ou bilatérale des paires craniennes en particulier de la 6e et la de 7e paires, parfois de la 5e de la 8e de la 9e et de la 10e paires, plus rarement de la 3e, de la 11e et de la 12e paires Lorsque ces paralysies des nerfs craniens s associent à une hémiplégie controlatérale, réalisant les différents types de syndromes alternes, la localisation au tronc cérébral est cliniquement certaine L absence de fièvre, de modification du liquide céphalo-rachidien et de l hémogramme oriente vers le gliome du tronc cérébral que confirmera l étude radiologique sans qu il soit besoin d attendre l apparition en tache d huile de nouveaux symptomes cliniques

Étude radiologique

L étude radiologique prend donc une place considérable dans l établissement d un diagnostic de certitude

Les clichés simples standard du crane, de face et de profil, complétés au besoin par des incidences spéciales, ont été réalisés chez tous nos patients Cette enquête s est révélée négative dans 44 cas dans 7 cas elle a montré une très discrète disjonction des sutures avec dans deux cas des impressions digitiformes assez accentuées Nous n avons jamais vu de calcification ni de modification de la selle turcique, ni d atteinte des structures osseuses de la base

C est donc aux examens neuro radiologiques plus spécialisés qu on demandera de fournir la preuve de la tumeur Dans 25 cas, le diagnostic a été posé par la ventriculographie seule dans 23 cas par l encéphalographie seule, dans 3 cas par l encéphalographie et la ventriculographie associées 6 de ces malades ont en outre subi des explorations artériographiques

Les modifications de l image du système ventriculaire sont les plus connues Tous les traités classiques, LINDGREN (1954), DECKER et coll (1960), ROBERT



a b

Fig 2 a) Cliché de profil d encephalographie Refoulement important de l aqueduct et du 4e ventricule ét rement de l aqueduc qui a perdu son coude habituel aplatissement de la citerne pré pontique le bord superieur du pont est emousse surélevé et empiete sur la citerne inter pedonculaire les citernes retropulvinari nnes sont un peu elarg es la moelle cervicale haute est infiltree et refoulée vers la part e posterieure du canal rachidien b) Cliche d face L aqueduc reste médian de même que le 4e ventricule qu apparait un peu elargi la vallécule est élargie et tres discrètement de iée vers la gauche les ventricules lateraux ne sont pas modifiés

son (1957), Ingraham et Matson (1954) Ruggiero (1957) reprennent dans les détails les signes que Sutton (1953) nous avait exposes precedemment et que nous allons revoir brièvement puisqu ils sont tres bien connus

Les principales anomalies apparaissent sur les clichés de profil l infiltration gliomateuse du tronc cerébral va provoquer un refoulement en haut et en arriere de l aqueduc de Sylvius et du 4e ventricule (Fig 2)

Le refoulement de l aqueduc peut paraitre discret ne depassant pas 4 a 5 mm mais l utilisation du repere de Lysholm (1935 1946) permet d objectiver avec precision l anomalie topographique En meme temps que se deplace ce conduit on voit se redresser et disparaitre le coude qu il dessine dans presque tous les cas chez l enfant normal Nous avons trouve ces modifications 31 fois sur 43 cas ou l aqueduc etait visible a l etude pneumographique Dans 10 cas l aqueduc etait en place mais son coude avait en partie disparu et le 4e ventricule etait refoule

Le refoulement en arriere du 4e ventricule constitue en effet le signe majeur le plus frequemment constate souvent outre son refoulement le plancher presente une convexite posterieure Ces anomalies sont quelquefois mieux accessibles apres tomographie L utilisation du procede propose par Schwarcz (1959) et par Ziedses des Plantes (1950) peut rendre des services dans les formes ou le plancher est peu déplace masque par la superposition des massifs petromastoidiens Nous avons trouve ce symptome radiologique 46 fois sur

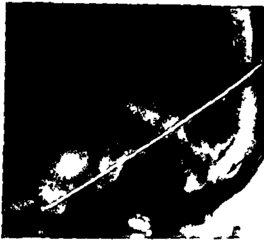


Fig 3 Cliniquement on s oriente vers un gliome infiltrant du tronc cérébral à localisation basse l encéphalographie de profil l aqueduc non refoulé 4e ventricule à peine refoulé (le repère de TWINING se projette au niveau du plancher ventriculaire) soulèvement important régulier de la paroi postérieure du bulbe au-dessous du trou de Magendie en une masse arrondie de la taille d une grosse noix engagée dans le trou occipital (flèches)

47 examens ou le 4e ventricule etait visible Dans 1 cas ni l'aqueduc ni le 4e ventricule n étaient refoulés, mais on voyait manifestement une augmentation de volume de la moelle cervicale haute et du bulbe au dessous du 4e ventricule (Fig 3)

Les clichés de face nous montrent par contre peu de modifications, fait important le 4e ventricule reste en situation médiane (Fig 2 b), parfois son plancher, du fait du deplacement tumoral, s elargit et presente une concavité anterieure habituellement symetrique (11 cas) Lorsque le developpement tumoral predomine lateralement la concavite du plancher s oriente vers le cote malade (2 cas) parfois la partie laterale du 4e ventricule s ampute ou s injecte mal (2 cas) En somme lorsque la tumeur se developpe unilateralement il n y a pas de refoulement lateral du 4e ventricule mais une sorte de torsion sur son axe De meme, nous n avons jamais vu de déplacement appreciable de l aqueduc de Sylvius ce conduit est toujours reste strictement médian sur tous les cliches de face en pneumographie, peut etre l utilisation de la ventriculographie lipiodolée nous aurait elle permis de mieux etudier ce canal et de saisir quelques discrets déplacements lateraux comme le mentionne SUTTON, qui semble attacher a cette constatation une grande valeur diagnostique

Le systeme ventriculaire supra tentoriel n est en general pas modifie Les ventricules lateraux et le 3e ventricule etaient de taille normale dans 27 cas tres discretement dilates dans 14 cas franchement mais moderement dilates dans 6 cas Lorsque la tumeur a une propagation haute vers les pédoncules cerebraux il arrive frequemment qu elle determine un soulevement de la partie posterieure du plancher du 3e ventricule l abouchement de l aqueduc dans le 3e ventricule se fait en un point anormalement elevé, le repere decrit par RUGGIERO et CASTELLANO (1953) nous a permis de constater l elevation de cet abouchement de l aqueduc chez 23 patients Si la propagation haute vers le thalamus est plus marquée encore, elle peut determiner un refoulement con



a b

Fig 4 a) Une première encéphalographie faite au moment de l hospitalisation ne montre pratiquement pas d image pathologique l 4e ventricule en particulier est sensiblement en place b) Deux mois plus tard l état du malade s étant progressivement aggravé une nouvelle exploration gazeuse ventriculographique est faite Refoulement postérieur du 4e ventricule dont la lumière paraît un peu aplatie

trolateral de la partie postérieure du 3e ventricule visible sur les clichés de face, et parfois un soulèvement du plancher du corps du ventricule latéral Nous avons constaté ces images dans 2 cas

Pour terminer nous envisagerons des signes ventriculaires que nous considérons comme accessoires car ils apparaissent seulement dans les formes où le refoulement postérieur et supérieur de l aqueduc et du 4e ventricule sont évidents

La distance du dos de la selle au 4e ventricule dépasse le chiffre de 3 9 cm défini comme normal par DAVIDOFF et EPSTEIN (1955)

La longueur de l aqueduc s accroît

La hauteur du 4e ventricule depuis son plancher jusqu au faîte diminue , nous l avons trouvée inférieure au chiffre de 1 4 cm dans 38 cas sur 47 où nous avons pu la mesurer alors que le chiffre normal fourni par DAVIDOFF et DYKE (1951) est de 1,6 cm ,

L angle ventriculaire défini par SUTTON a été trouvé supérieur à 80 dans 32 cas

Enfin dans un cas nous avons constaté une dilatation de l aqueduc avec ébauche d un petit ventricule à son niveau

L étude des citernes lors de l encéphalographie apporte également de très intéressants renseignements Le signe le plus classique nous l avons retrouvé dans 27 cas sur 32 où les citernes étaient injectées est représenté par le refoulement et l écrasement de la citerne pré pontique (Figs 2 6 7 9) et de la citerne pré bulbaire celle ci n étant pas toujours visible En réalité ce symptôme n a pas de spécificité puisque tout processus occupant de l espace développé dans



Fig. 3. Cliniquement on s'oriente vers un gliome infiltrant du tronc cérébral à localisation basse. L'encéphalographie de profil : l'aqueduc non refoulé, 4e ventricule à peine refoulé (le repère de TWINING se projette au niveau du plancher ventriculaire) ; soulèvement important régulier de la paroi postérieure du bulbe au-dessous du trou de Magendie en une masse arrondie de la taille d'une *grosse noix engagée dans le trou occipital* (flèches).

47 examens où le 4e ventricule était visible. Dans 1 cas ni l'aqueduc ni le 4e ventricule n'étaient refoulés, mais on voyait manifestement une augmentation de volume de la moelle cervicale haute et du bulbe au dessous du 4e ventricule (Fig. 3).

Les clichés de face nous montrent par contre peu de modifications, fait important, le 4e ventricule reste en situation médiane (Fig. 2 b) ; parfois son plancher, du fait du déplacement tumoral, s'élargit et présente une concavité antérieure habituellement symétrique (11 cas). Lorsque le développement tumoral prédomine latéralement, la concavité du plancher s'oriente vers le côté malade (2 cas) ; parfois la partie latérale du 4e ventricule s'ampute ou s'injecte mal (2 cas). En somme lorsque la tumeur se développe unilatéralement, il n'y a pas de refoulement latéral du 4e ventricule mais une sorte de torsion sur son axe. De même nous n'avons jamais vu de déplacement appréciable de l'aqueduc de Sylvius : *ce conduit est toujours resté strictement* médian sur tous les clichés de face en pneumographie ; peut-être l'utilisation de la ventriculographie lipiodolée nous aurait-elle permis de mieux étudier ce canal et de saisir quelques discrets déplacements latéraux comme le mentionne SUTTON, qui semble attacher à cette constatation une grande valeur diagnostique.

Le système ventriculaire supra tentoriel n'est en général pas modifié. Les ventricules latéraux et le 3e ventricule étaient de taille normale dans 27 cas, très discrètement dilatés dans 14 cas, franchement mais modérément dilatés dans 6 cas. Lorsque la tumeur a une propagation haute vers les pédoncules cérébraux, il arrive fréquemment qu'elle détermine un soulèvement de la partie postérieure du *plancher du 3e ventricule* : *l'abouchement* de l'aqueduc dans le 3e ventricule se fait en un point anormalement élevé ; le repère décrit par RUGGIERO et CASTELLANO (1953) nous a permis de constater l'élévation de cet abouchement de l'aqueduc chez 23 patients. Si la propagation haute vers le thalamus est plus marquée encore, elle peut déterminer un refoulement con



Fig 9 Voir fig 8 Il existe à la face antérieure du pont un profond sillon creusé par le tronc basilaire avec proliférations de part et d autre de ce vaisseau de végétations tumorales (C et D)

pathognomonique chez l enfant Chez l adulte en effet un tel deplacement peut etre du a un *neurinome* de l *acoustique*, a un *méningiome* du *clivus* a un chordome a un anévrysme du tronc basilaire Chez l enfant ces tumeurs sont pratiquement inexistantes En 10 ans d experience a l Hopital des Enfants Malades, nous n avons observé que 2 cas de refoulement simulant celui d une tumeur du tronc cerebral l un au cours d un volumineux cranio-pharyngiome a developpement postérieur engage dans l incisure tentorielle l autre dans une tumeur du plancher du 3e ventricule mais avec refoulement posterieur du tronc basilaire a l arteriographie , dans l un et l autre cas d ailleurs la sympto matologie clinique etait foncierement differente de celle que determinent les gliomes du tronc cerebral Aussi pensons nous que, chez l enfant, lorsque les signes neurologiques evoquent une tumeur du tronc, le deplacement posterieur de l aqueduc et du 4e ventricule a une valeur diagnostique formelle

Comment interpreter les deplacements de l aqueduc et du 4e ventricule lorsqu ils sont discrets lorsque l aqueduc se situe au niveau de repere de LYSHOLM lorsque le point milieu de la ligne de TWINING ne se situe pas nettement en avant du plancher du 4e ventricule c est la un des problemes les plus délicats qui se soient posés a nous En effet nous avons pu constater comme l affirme LINDGREN (1954) que les tumeurs du tronc authentiques peuvent pendant plusieurs mois ne determiner aucune modification aucun déplacement du 4e ventricule et de l aqueduc Une de nos observations nous en fournit un exemple puisqu il a fallu attendre une troisieme exploration gazeuse un an apres la premiere pour saisir un refoulement appreciable de l aqueduc de Sylvius

Le probleme se complique du fait de l existence au niveau du tronc cerebral de lésions pseudo tumorales dont la symptomatologie clinique est absolument identique à celle des gliomes infiltrants FILHO et PIMENTA (1950) en rapportent un bel exemple BERNARD (1952) precise que les encephalites consecutives a

des fievres eruptives, les encephalites aiguës primitives du type de la polio encéphalite de von Economo ou de la pan encéphalite autochtone de Pette & Doring, que les leucoencéphalites progressives telle que la leucoencéphalite subaigue de von Bogaert, l encéphalite concentrique de Balo, la maladie de Schilder Foix et enfin de nombreuses autres leucodystrophies sont susceptibles de simuler cliniquement une tumeur du tronc cérébral

Nous avons exploré par pneumographie 6 patients suspects d après les signes neurologiques de tumeur du tronc cérebral , dans 3 cas l absence totale de modification de l'image pneumographique avait fait mettre en doute le diagnostic, et spontanément, sans traitement roentgenthérapique, la disparition totale des signes neurologiques apres quelques semaines nous a donné raison Dans 3 autres cas par contre, sur de tres discrets signes ventriculographiques, nous avons évoque la possibilite d une tumeur du tronc cérebral deux de ces patients ont guéri en quelques semaines, pratiquement sans sequelle neurologique, en l absence de tout traitement roentgenthérapique, avec un recul de 7 et 8 ans , le troisieme malade a guéri sans sequelle egalement mais il avait reçu trois seances de roentgen therapie et nous ne possedons pour lui qu un recul de 2 ans

Ces encéphalites pseudo tumorales du tronc cérébral posent donc aux radiologistes et aux cliniciens le probleme diagnostique le plus angoissant , nous pensons avec DECKER (1960) que l on doit pour affirmer le diagnostic de gliome du tronc cerebral n accepter que des signes ventriculographiques nets

Les tumeurs du plancher du 4e ventricule a developpement intra ventriculaire peuvent simuler sur les cliches de profil un refoulement posterieur du 4e ventricule et de l aqueduc Cependant l image est en regle differente du fait de l'aspect bosselé, mammelonné du plancher ventriculaire , d autre part ces neoformations bouchent rapidement l aqueduc et provoquent dans la grande majorité des cas une dilatation des ventricules lateraux et du 3e ventricule SUTTON mentionne qu une malformation angiomateuse peut simuler une tumeur du tronc cerebral ce probleme ne s est jamais pose a nous , de meme nous soulignerons l extreme rarete de l hemangioblastome du plancher du 4e ventricule chez l enfant

Il reste a envisager les refoulements de l aqueduc et du 4e ventricule liés a une invagination basilaire ils accompagnent en fait cette malformation osseuse lorsqu elle est evidente et ne pose alors pas de difficulte, surtout si l on dispose en meme temps de l image cisternale Il est prudent toutefois si l on voit sur les films ventriculographiques l image de l aqueduc et du 4e ventricule moderément refoules, de rechercher une invagination basilaire en construisant les reperes habituels

Pour terminer, nous devons envisager le choix d une enquete neuro radiologique en vue du di[illegible] des [illegible] du tronc cerebral Comme la plupart des auteurs, en [illegible] coll (1957), STABERT et coll (1959) nous pensons que [illegible] année au moule le tronc cérébral

par l'aqueduc et le 4e ventricule en arrière, et par le système cisternal en avant, constitue l'examen de choix. Toutefois, chez le jeune enfant non coopérant, cette enquête nécessite, pour être conduite selon les modalités maintenant classiques, une anesthésie générale. Cette narcose n'est pas sans risque chez ces enfants qui présentent parfois, du fait de leur localisation tumorale, des troubles neuro-végétatifs, en particulier respiratoires. Un de nos patients, dans ces circonstances, mourut au décours de l'examen par aggravation des troubles respiratoires, alors qu'il n'avait pas d'hypertension intra-cranienne et qu'on avait pu éliminer radiologiquement l'éventualité d'un engagement amygdalien ou temporal.

Aussi croyons-nous préférable, dans les cas où, chez le jeune enfant, existent d'importants troubles neuro-végétatifs, d'avoir recours à la ventriculographie gazeuse, au besoin complétée quelques jours plus tard par une cisternographie simple qui ne nécessite pas d'anesthésie.

La ventriculographie lipiodolée, l'artériographie vertébrale ne trouvent d'indications que dans de très rares cas particuliers, lorsque les examens précédents sont négatifs ; encore ne faut-il pas en attendre de grands renseignements. Toutefois la ventriculographie lipiodolée aurait, selon DILENGE et coll. (1960), l'avantage de mieux objectiver les déformations de l'aqueduc et du 4e ventricule et permettrait en particulier une meilleure localisation en vue du traitement roentgenthérapique (DILENGE, communication personelle).

Telles sont les constatations que nous permet l'analyse détaillée d'une série de 51 observations. Il nous paraît prudent en effet de nous entourer de toutes les garanties avant d'affirmer radiologiquement un diagnostic qui comporte, nous le savons, un pronostic fatal inéluctable avec une survie moyenne de 6,2 mois pour les sujets non traités, de 10 mois pour les sujets ayant été soumis à un traitement roentgenothérapique.

RÉSUMÉ

Les manifestations neuro-radiologiques des tumeurs du tronc cérébral chez l'enfant sont étudiées sur une série de 51 cas, tous décédés, dont 11 cas vérifiés anatomiquement. La pneumo-encéphalographie est certainement la meilleure enquête pour porter le diagnostic et lorsque le système ventriculaire ne s'injecte pas, l'analyse attentive des citernes prépontique, inter-pédonculaire et du tronc cérébral apporte souvent des arguments probants. L'artériographie vertébrale par contre est infidèle et parfois trompeuse.

SUMMARY

The neuroradiologic findings were studied in a material of 51 children who had died from tumours of the brain stem; in 11 of these the diagnosis had been confirmed. Pneumo-encephalography is certainly the investigation of choice, and when the ventricular system is not filled, a careful study of the pontine, intercrural and basal cisterns often affords conclusive information. Vertebral angiography on the other hand is unreliable and may sometimes prove misleading.

ZUSAMMENFASSUNG

Es wurden die neurologischen Befunde von 51 Kindern studiert die an Tumoren des Hirnstammes gestorben sind Bei 11 von ihnen wurde die Diagnose bestatigt Pneumo-Encephalographie ist sicherlich die Metode der Wahl und falls das Ventrikelsystem nicht gefullt wird kann durch eine sorgfaltige Studie der pontinen intercruralen und basalen Cisternen eine uberzeugende Information gewonnen werden Vertebrale Angiographie ist andererseits unzuverlassich und mag manchmal Anlass zu einer Fehldiagnose geben

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ANGIOGRAPHIC CHANGES ASSOCIATED WITH A DILATED TEMPORAL HORN

by

MARJORIE J LEMAY and ROBERT G OJEMANN

Incomplete or intermittent obstruction of the temporal horn by tumors or inflammatory lesions causing localized dilatation of its tip is not rare, but unilateral hydrocephalus due to complete obstruction of a lateral ventricle by tumor or adhesions must be uncommon CAIRNS and co-workers (1947) reported four cases of localized hydrocephalus of the temporal horn occurring in soldiers as a complication of penetrating wounds of the parietal lobe involving the lateral ventricle It appeared that with healing of the parietal lobe lesion the body of the lateral ventricle became obliterated and the inferior horn formed a huge cyst because of obstruction to the outflow of cerebrospinal fluid RUSSELL (1949) in her classical monograph on the pathology of hydrocephalus reviewed a fifth case This was in a 7 month old infant and was due to occlusion of the body of the lateral ventricle by adhesions which probably followed hemorrhage

An enlarged inferior horn of the lateral ventricle due either to complete or incomplete obstruction, may appear as a mass lesion The site of the obstruction will easily be demonstrated by pneumoencephalography but many neurological centers now depend primarily on cerebral angiography for the localization of mass lesions The changes in the angiograms can be misleading and we would like, therefore, to review some of the arterial changes which may



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Fig 1 A case in which the anterior cerebral artery was small and filled with contrast material only when cross compression of the other carotid artery was used during the injection a) Lateral arteriogram. The anterior choroidal artery is underlined by a solid line The dotted line delineates the superior extent of the sylvian fissure The posterior temporal artery (2) in this case arises from the sylvian artery (3) The posterior parietal artery (4) is in this case the terminal portion of the branch of the middle cerebral artery giving rise to the insular arteries b) A p arteriogram The anterior choroidal artery (→) and the anterior temporal branch of the middle cerebral artery (↔)

be present with unilateral obstructive hydrocephalus The branches of the middle cerebral artery and the anterior choroidal artery are the vessels most constantly distorted by the enlarged temporal horn and a brief review of their normal anatomy follows

Normal arterial anatomy

Middle cerebral artery From its origin at the bifurcation of the internal carotid the middle cerebral artery curves laterally and slightly anteriorly and then turns with a fairly sharp curve to enter the sylvian fissure

In the lateral arteriogram (Fig 1a) the middle cerebral artery group is seen to contain two main branches which run in the sylvian fissure posteriorly and upward from the level of the carotid siphon Less often there are one or even three main branches instead of the usual two At the posterior end of the fissure the vessels turn laterally and undulate as they pass through sulci onto the lateral surface of the brain The most constant of the main branches is the main termination of the middle cerebral artery it is sometimes called the sylvian artery or the artery of the angular gyrus It usually gives off a posterior parietal branch and then its terminal branches extend over the posterior superior

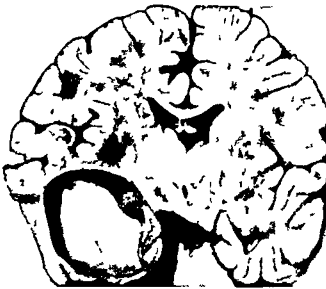


Fig 2 Pathologic appearance in a case of unilateral enlargement of the temporal horn Courtesy of DOROTHY RUSSELL

temporal and posterior parietal regions The next most constant branch is the posterior temporal artery, the proximal part of which also runs in the lower portion of the sylvian fissure more or less parallel to the sylvian artery It can usually be identified easily because it forms a hairpin curve, as described by LINDGREN (1957) as the artery turns upward and laterally to pass through the horizontal limb of the sylvian fissure and then down over the temporal operculum It usually leaves the sylvian fissure at about the mid point of the fissure and extends posteriorly over the posterior temporal and occipital regions of the surface of the brain

The mass of vessels lying in the sylvian fissure are small and arise either directly from the sylvian artery or, more commonly, from a branch or branches which run parallel to its anterior portion These vessels can usually be identified individually from the description given in the monograph published many years ago by MAURICE LEVY (1927) They extend upward to the top of the sylvian fissure and there loop sharply and are directed downward, and then *pass laterally through the horizontal limb of the fissure and onto* the surface of the brain over the frontal operculum These vessels overlie the island of Reil and were aptly called the 'insular arteries by KRAYENBUHL & RICHTER (1952) Since the sylvian artery and the posterior temporal artery lie in the lower portion of the sylvian fissure and the insular arteries define the top of the sylvian fissure a fairly accurate idea of the size and shape of the sylvian fissure can be obtained from the lateral arteriogram Because the sylvian *fissure* narrows posteriorly the middle cerebral group forms a rough triangle in the lateral view



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Fig 3 Arteriograms from Case 1 showing a dilated temporal horn (outlined by air) due to partial obstruction Anterior choroidal artery indicated by arrows

In the a p view (Fig 1b), several very small arteries can often be seen arising from the middle cerebral artery near its origin They enter the anterior perforated substance A larger vessel the anterior temporal artery, is usually given off before the main artery enters the fissure The anterior temporal artery, and often the posterior temporal artery can be distinguished from the sylvian and insular arteries Occasionally the two temporal arteries arise from a common branch The sylvian artery can usually be distinguished from the insular arteries because it is relatively straight larger in size, and because it forms a gentle curve over the island of Reil It can be seen leaving the posterior part of the fissure and going laterally onto the surface of the brain

Anterior choroidal artery The anterior choroidal artery in the a p view can be seen to arise from the medial side of the internal carotid artery just before its bifurcation The artery curves slightly medially and upward as it passes over the uncus and then abruptly curves laterally to enter the choroid plexus of the temporal horn It then curves posteriorly in the temporal horn

In the lateral view the anterior choroidal artery can be seen to arise most often from the distal portion of the internal carotid just above the posterior communicating artery and to extend in a gentle curve, usually S shaped superiorly and posteriorly to pass over the medial margin of the uncus The artery then sharply turns laterally and enters the temporal horn Here it passes posteriorly to end in the region of the glomus of the choroid plexus The

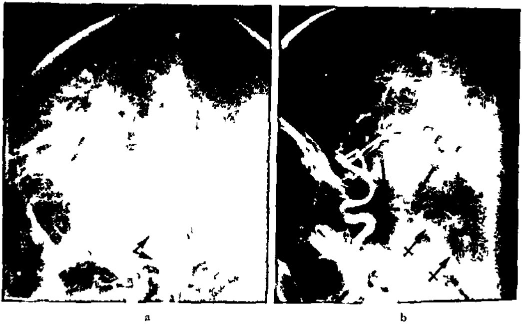


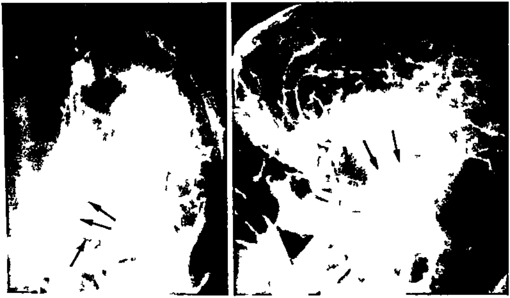
Fig 4 Arteriograms from Case 2 Anterior choroidal artery (→) the temporal branch of the posterior cerebral artery (+→) is displaced downwards

anatomy of the artery as seen on arteriography and at dissection, has been described by SJOGREN (1956) On arteriograms the anterior choroidal artery appears to be about the same size as the insular arteries It is easily identified in most lateral views, but it is often difficult to see in the a p views *It is of* diagnostic importance that the first portion of the artery lying in the inter peduncular subarachnoid cistern has a gentle curve but as the artery enters the temporal horn several short kinks are usually seen, particularly in the a p view (Fig 1b)

Cases illustrated

That the enlarged temporal horn can act as a mass lesion is illustrated in Fig 2 a coronal *section from the patient reported by* RUSSELL *The enlarged ventricle has* elevated the sylvian fissure and would therefore be expected to have elevated the anterior portion of the middle cerebral artery The hippocampal gyrus is displaced medially This should cause the proximal portion of the anterior choroidal artery the cisternal portion to be stretched and displaced medially

Case 1 In Fig 3 an enlarged temporal horn due to partial obstruction is illustrated This occurred in a 47 year old man with a history of seizures and loss of consciousness for 14 years He was lethargic and confused and his reflexes were decreased on the right side Pneumoencephalography had been carried out as the initial procedure and air remained in the anterior *horn of the right lateral ventricle and in the dilated tip of the left temporal horn* The proximal portion of the middle cerebral artery was elevated The first portion of the anterior choroidal artery was slightly straightened but the artery turned laterally as normal and entered the temporal horn



a b

Fig 5 Arteriograms from Case 3 There was complete obstruction of the temporal horn The anterior choroidal artery is indicated by arrows

On the lateral film (Fig 3b) the middle cerebral artery group was again elevated and the cisternal portion of the anterior choroidal artery was stretched although it kinked normally as it entered the temporal horn At the pneumoencephalographic examination a left centrally placed tumor was seen extending into the posterior temporal lobe The location of the tumor and enlargement of the anterior temporal horn were confirmed at operation

Post mortem examination showed that the main mass of the remaining tumor involved the septum pellucidum the white matter of the left frontal lobe and the left side of the mid brain pons and thalamus No tumor was present in the tip of the temporal lobe

Case 2 The second patient was a 39 year-old man admitted with a history of headache loss of memory and apathy There was bilateral papilledema left facial weakness and left homonymous hemianopsia

An a p arteriogram (Fig 4a) showed the anterior portion of the middle cerebral artery to be elevated and the vessels in the anterior sylvian fissure to be slightly medial to their usual position The cisternal portion of the anterior choroidal artery was stretched but the artery kinked normally as it entered the temporal horn

On the lateral view (Fig 4b) a lesion in the posterior temporal occipital area was indicated by the downward and medial displacement of the temporal branch of the posterior cerebral artery Again elevation of the middle cerebral artery was seen and the cisternal segment of the anterior choroidal was stretched The elevation of the middle cerebral artery suggested that the tumor extended into the tip of the temporal horn but the changes in the anterior choroidal artery contradicted this conclusion

At operation an astrocytoma grade II was found at a depth of about 2 cm extending from the mid temporal into the occipital region A small cyst was found at the anterior portion of the tumor from which about 10 ml of fluid was removed It is possible that the cyst was the blocked temporal horn No tumor was present in the anterior temporal lobe at operation to



a b

Fig 6 Arteriograms in early temporal lobe tumor Anterior choroidal artery is indicated by arrows in (a) its appearance is similar to that in fig 4a

account for the elevation of the middle cerebral artery We believe the arteriographic changes were most likely caused by a blocked ventricle

Case 3 Complete obstruction of the temporal horn was found in the third case a 44-year-old man with seizures characterized by the sudden onset of headaches and nausea followed by numbness and weakness in the right extremities The neurologic examination was normal but the EEG showed a left anterior temporal focus and the CSF protein was 120 mg %

In the a p arteriogram (Fig 5a) the anterior segment of the middle cerebral artery was elevated The cisternal portion of the anterior choroidal artery was stretched and displaced medially The proximal plexal section of the choroidal artery was normally kinked and was not stretched Distally the artery extended laterally to a near normal position

In the lateral view (Fig 5b) there was marked elevation of the middle cerebral artery and narrowing of the sylvian fissure as shown by narrowing of the triangle usually formed by the insular arteries The anterior portion of the anterior choroidal artery was stretched No tumor was seen Except for the normal shape of the distal anterior choroidal artery the findings suggested a mass lesion in the temporal lobe

At operation a meningioma was found in the posterior portion of the lateral ventricle with complete obstruction and marked dilation of the temporal horn The patient made a satisfactory recovery We would expect his lesion to have appeared very much like that illustrated by Russell (Fig 2)

Discussion

The elevation and medial displacement of the anterior portion of the middle cerebral artery found in these cases resembled the findings with a temporal lobe tumor The difference resided in the changes in the course of the anterior choroidal artery The cisternal portion of the latter artery was stretched and displaced medially by the dilated temporal horn but the plexal portion of the anterior choroidal artery lay within the dilated horn and was not displaced



a b

Fig 7 Arteriograms of the same case as shown in fig 6 carried out one year later Anterior choroidal artery is indicated by arrows

A tumor in the tip of the temporal lobe large enough to elevate the middle cerebral artery causes the plexal part of the anterior choroidal artery as well as its cisternal portion to be straightened and inwardly displaced This is shown in Fig 6 which is from a patient with temporal lobe seizures The initial examination (Fig 6a) revealed the anterior part of the anterior choroidal to be displaced medially while the middle cerebral vessels were still in their normal position As the tumor enlarged (Fig 7) the entire anterior choroidal artery, including its plexal portion, was stretched and medially displaced and the middle cerebral artery complex became elevated

Edema of the temporal lobe secondary to a cerebral vascular accident or distant brain abscess also causes upward and medial displacement of the middle cerebral artery and may easily be mistaken for an obstructed temporal horn or tumor mass In such cases the anterior choroidal artery may be medially displaced in the a p arteriogram but it will not be stretched

Other lesions which might be confused on arteriography with an obstructed temporal horn, are generalized hydrocephalus and cerebral atrophy In cases of obstructive hydrocephalus the bodies of the lateral ventricles are usually enlarged proportionately more than the temporal horns and the changes in the arteriograms are mainly due to the dilated body of the lateral ventricle Enlargement of the temporal horn due to cerebral atrophy causes only minimal changes in the anterior choroidal and middle cerebral arteries The changes with atrophy are generalized throughout the hemisphere The sylvian fissure is enlarged Consequently, there is no elevation of the middle cerebral or displacement of the anterior choroidal artery

Acknowledgement

The authors wish to express their appreciation to Dr John H Drew Chief of the Neurosurgical Service Boston Veteran s Administration Hospital for permission to report the cases from his service We also wish to thank Drs Fred A Quadfasel Joseph M Segarra and Joseph B Bittenbender for their advice and interest in the preparation of this article

SUMMARY

A dilated temporal horn due to complete or intermittent obstruction may simulate a mass lesion by causing elevation of the anterior portion of the middle cerebral artery and stretching and inward displacement of the cisternal portion of the anterior choroidal artery The dilated temporal horn may be distinguished by the normal course of the plexal portion of the anterior choroidal artery The arteriographic changes in three cases with enlarged temporal horns are presented These changes are compared to and distinguished from the arteriographic findings in anterior temporal lobe tumors and edema obstructive hydrocephalus and cerebral atrophy

ZUSAMMENFASSUNG

Die Dilatation eines Temporalhornes nach totaler oder intermittenter Obstruktion kann einen Tumor vortauschen da der vordere Teil der A cerebri media angehoben und gestreckt sowie die cysternale Strecke der A choroidea ant nach einwarts verlagert ist Das dilatierte Temporalhorn unterscheidet sich vom Tumor durch den normalen Verlauf des Stammes der A choroidea anterior Es werden die arteriographischen Veranderungen bei 3 Fallen von vergrossertem Temporalhorn mit den Befunden bei vorderen Temporallobstumoren Ödem obstruktivem Hydrocephalus und cerebraler Atrophie verglichen und die Unterschiede hervorgehoben

RÉSUMÉ

Une corne temporale dilatée par obstruction complete ou intermittente peut simuler une tumeur en déplaçant vers le haut la partie antérieure de l artere cérébrale moyenne et en étirant et en déplaçant en dedans la partie cisternale de l artère choroidienne antérieure Le trajet normal de la partie plexuelle de cette artere permet de reconnaitre qu il s agit d une dilatation de la corne temporale Les auteurs comparent les signes artériographiques de trois cas de dilatation de la corne temporale et les différencient des signes des tumeurs et de l oedeme antérieurs du lobe temporal de l hydrocèphalie obstructive et de l atrophie cérébrale

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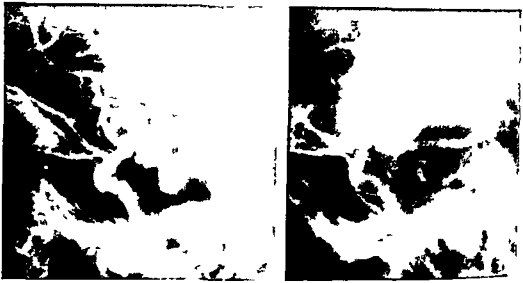
ARTERIOGRAPHIC STUDIES IN ANEURYSM OF THE INTERNAL CAROTID ARTERY TREATED BY CAROTID OCCLUSION

by

LEON MORRIS

The present investigation was undertaken in order to assess arteriographically the response of aneurysms arising from the internal carotid artery to treatment by occlusion of the carotid artery in the neck Since the natural history of these aneusysms, when treated conservatively is difficult if not impossible, to assess it was considered that reduction in size of the aneurysm following upon carotid occlusion represented a favourable response to treatment

Material The series consists of 29 cases in which there were a total of 35 aneurysms All the cases had suffered at least one subarachnoid haemorrhage Twenty seven aneurysms were situated on the internal carotid artery at or near the origin of the posterior communicating artery Four aneurysms were at the internal carotid bifurcation Two cases had bilateral posterior communicating aneurysms, only one aneurysm in each of these cases was treated The four remaining aneurysms comprised three middle cerebral and one anterior communicating aneurysm These four aneurysms do not form part of the series The series is unselected in so far as it represents all cases in which follow up arteriograms were done during the three year period November 1957 to October 1960



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Fig 1 Case of subarachnoid haemorrhage in a male a) Left carotid arteriography Large bilocular posterior communicating aneurysm b) Vertebral arteriography two years after the left common carotid artery had been ligated. An aneurysm different in size shape and position from the original aneurysm probably an entirely different aneurysm The internal carotid artery although not palpable, was seen to fill.

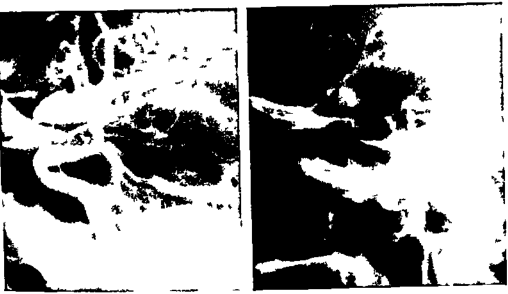
Treatment There were four main lines of treatment (1) partial or temporary occlusion of the common carotid artery, (2) common carotid artery ligation, (3) internal carotid artery ligation, and (4) one or more of the above methods in sequence

Arteriographic follow-up Thirty-nine follow-up arteriographies were carried out Every case had at least one follow-up study, six cases had two, and two cases had three Follow up was done from 5 days to two years after the operation with a mean of 5 25 months

Follow up arteriographies were carried out either by the carotid or vertebral routes Twenty two vertebral arteriographies were performed (15 by direct vertebral puncture and 7 by retrograde subclavian injection) In all these cases the carotid artery was impalpable or so small and involved by fibrous tissue that it could not be punctured directly Not all these cases had complete carotid artery occlusion and in some a small internal carotid artery was seen to fill either through collateral circulation between the vertebral and external carotid arteries in the neck or retrograde from the carotid siphon

In 17 cases the carotid artery on the treated side was palpable and was punctured directly

Early in the series attempts were made to fill the carotid siphon on the treated side by injection of the contralateral internal carotid artery It was found that this filling never occurred and this procedure was discontinued



a b

Fig 2 Subarachnoid haemorrhage in a female aged 32 a) Right carotid arteriography Large an eurysm at the internal carotid bifurcation b) Vertebral arteriography 5 months after the common carot d artery had been ligated Cons derable reduction in the size of the aneurysm The internal carotid artery although not palpable was seen to fill

Results

These were assessed under two main headings

1 The degree of filling by contrast medium of the parent vessel from which the an eurysm originally arose, and thus the reliability of the post operative arteriogram in the assessment of the progress of the aneurysm In all cases in which the carotid artery could be punctured directly filling of the parent vessel was excellent (Figs 3b and 4b) In those cases in which vertebral arteriography was done, 19 showed adequately filled parent vessels (Figs 1b, 2b and 3d) In two cases the parent vessel was only poorly filled, and in one the parent vessel was not seen to fill although in this latter case, despite the fact that the parent vessel was not seen the aneurysm itself was seen (Fig 3c)

These findings established the reliability of the post operative studies and we felt justified in proceeding to the second aspect of the follow up study

2 Comparison of the pre and post operative appearances of the aneurysms with particular reference to their size and shape Only the final results to date have been assessed Where a case had more than one form of occlusive treatment the intermediate results between each form of treatment are not reflected in the results it being assumed that a second or third form of treatment was necessary as a result of a poor response to the primary treatment

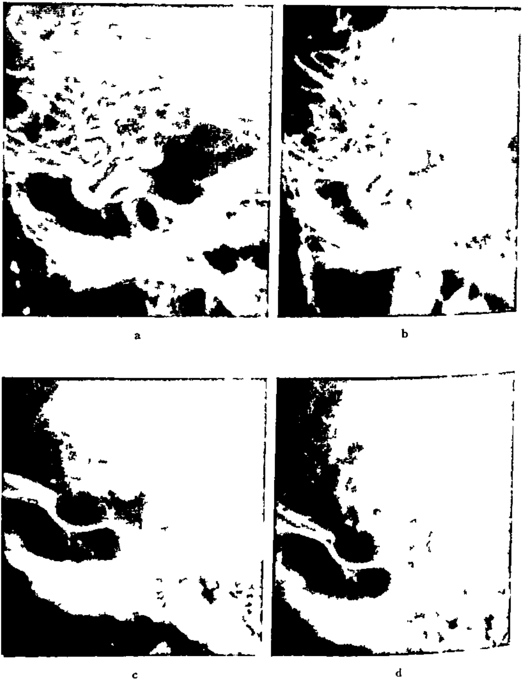


Fig 3 Subarachnoid haemorrhage with a right third cranial nerve palsy in a female aged 43 a) Right carotid arteriography Large posterior communicating aneurysm b) The common carotid artery was occluded for 4 days after which the occluding clamp was released and the carotid arteriography was repeated Little change in the size of the aneurysm c) Vertebral arteriography 3 months after the common carotid artery had been ligated The aneurysm is still present d) Vertebral arteriography 3 months after the internal carotid artery had been ligated The aneurysm is much smaller

Table

Post-operative arteriographic assessment of 29 cases of posterior communicating aneurysm following carotid occlusion in the neck

State of aneurysm	Internal carotid artery occluded	Common carotid artery occluded	Carotid system patent
Markedly smaller (18 cases)	10 cases	7 cases	1 case
Slightly smaller (7 cases)	2 cases	2 cases	3 cases
Unchanged (2 cases)	1 case	—	1 case

No assessment parent vessel too poorly seen in 2 cases

The results are shown in the accompanying Table In 18 cases the aneurysm was markedly smaller, and in seventeen of these either the internal or common carotid artery was found to be completely occluded In 7 cases in which the aneurysm was only slightly smaller, four showed complete arterial occlusion Thus it can be seen that where complete occlusion of the internal carotid or common carotid arteries is achieved the results are extremely good whereas where the whole carotid system remains patent after temporary or partial occlusion the results are less gratifying

It was not easy to assess what part an internal carotid artery, which although not palpable, filled through collaterals or in a retrograde fashion after vertebral injection was actually contributing to the filling of the parent vessel from which the aneurysm originally arose (Figs 1b and 2b) It was assumed that, where a vessel was demonstrated in this manner, it was probably contributing little to the maintenance of blood flow or pressure in the parent vessel Nevertheless provided that a vessel was seen in the post operative angiogram it was considered to be anatomically if not dynamically patent, and was reflected in the results as being patent

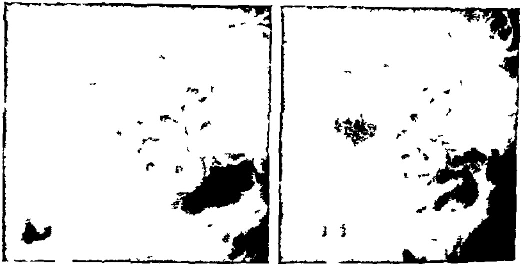
Three aneurysms showed alteration in shape as well as in size

Of the 29 patients 27 are alive and without recurrence of the haemorrhage One is dead from a subsequent haemorrhage and another has had one non fatal haemorrhage

Five cases had post operative sequelae attributable to the operation One followed internal carotid ligation two followed common carotid ligation and two followed temporary carotid occlusion Four of these had excellent cross flow on cross compression test at the initial examination

Discussion

We feel that this method of post operative assessment is valuable Our results generally are in agreement with those reached by Mount & Taveras (1956) using a similar arteriographic assessment and also with those of McKissock Richardson & Walsh (1960) who assessed the results of carotid ligation in posterior communicating aneurysm clinically



a b

Fig 4 Subarachnoid haemorrhage with a left third cranial nerve palsy in a female aged 65 a) Left carotid arteriography A bilocular posterior communicating aneurysm b The left common carotid artery was occluded for 4 days and following the removal of the occluding clamp a repeat carotid arteriography was performed Only the anterior loculus of the aneurysm was filled

Acknowledgement

I am indebted to Mr J R. Gibbs of the South East Metropolitan Regional Neurosurgical Unit who has co-operated so wholeheartedly with me in this study

SUMMARY

Twenty nine cases of posterior communicating aneurysm have been assessed arteriographically following occlusion of the carotid artery in the neck This method of assessment is valuable and the efficacy of the treatment is confirmed

ZUSAMMENFASSUNG

Neunundzwanzig Falle von hinteren kommunizierenden Aneurysmen wurden nach Verschluss der Art carotis in der Halsregion arteriographisch ausgewertet Diese Methode ist wertvoll und sie bestatigt den therapeutischen Effekt

RÉSUMÉ

Trente neuf cas d anevrisme de l artere communicante postérieure ont été examines par artériographie apres ligature de l artere carotide dans le cou Cette méthode d examen est utile et l efficacité du traitement est confirmee

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DIFFERENTIAL DIAGNOSIS OF SPACE OCCUPYING LESIONS IN THE REGION OF THE THALAMUS BY CEREBRAL ANGIOGRAPHY

by

D GORDON POTTS and JUAN M TAVERAS

The vascular displacements due to tumors arising in or near the thalamus may be logically predicted from a knowledge of the exact relationships of the vessels to the thalamus Recognition of these tumors by angiography is of some importance because in many hospitals angiography is the diagnostic procedure used if a supratentorial tumor is suspected particularly if there are lateralizing signs

A number of authors have discussed the changes caused by deeply situated tumors investigated by angiography JOHANSON (1954) gave a good description of the effects produced by central expanding processes LAINE et coll (1956) discussed the methods of measuring the position of the internal cerebral vein in the lateral view and described a template which may be used to demonstrate changes in the position of the junction of the thalamostriate and internal cerebral veins A template was also used by WOLF NEWMAN and SCHLESINGER (1955) to demonstrate changes in the location of the internal cerebral vein in the lateral view RIEMENSCHNEIDER and ECKER (1954) discussed the opening of the venous angle between the thalamostriate and internal cerebral veins when

the tumor arises in the head of the caudate nucleus or anterior thalamus These changes were also discussed by RING (1959)

It is the purpose of this communication to analyze these findings and determine the frequency with which the changes occur in a series of 59 tumors in or near the thalamus An attempt is made to show how all of these changes might be expected from a consideration of the normal anatomy Some differential diagnostic criteria are suggested to distinguish thalamic tumors from other deeply placed masses It is felt that recognition of thalamic tumors is important because operation or needling of them may be dangerous

Material In a series of 6 048 tumors of the central nervous system investigated in 15 years from 1945 to 1960 at the Neurological Institute, New York there were 53 thalamic tumors (an incidence of 0 9 %) However, only 19 of these were studied by angiography The rest were demonstrated by air studies only and are not included in this report In addition, 40 cases of masses around the thalamus, many of which may have arisen in the thalamus, subsequently to extend into adjacent areas, and 3 cases of ventricular dilatation investigated by angiography, were reviewed and the changes compared with those produced by pure thalamic masses The case material has been divided as shown below

		Number of cases
I	Pure thalamic tumors	19
II	Thalamic tumors also involving adjacent structures	
	Fronto thalamic	5
	Parieto thalamic	6
	Temporo thalamic	10
	Hypothalamic	3
III	Thalamic extending into upper brain stem	1
IV	Juxta thalamic tumors extending into the third ventricle or lateral ventricles	
	Tumors in the lateral ventricles	2
	Tumors of the septum pellucidum	4
	Colloid cysts of the third ventricle	2
	Pinealomas or tumors of this region	3
	Tumors in the third ventricle	2
V	Deep tentorial meningiomas	2
VI	Ventricular dilatation	3
	Total	62

Anatomical considerations The vessels which are related to the thalamus and other deep structures are the pericallosal middle cerebral posterior cerebral anterior choroidal, posterior choroidal and lenticulostriate arteries, and the internal cerebral, thalamostriate basilar septal choroidal veins and the vein of Galen

In general, the vessels which lie closest to the thalamus will be displaced



Fig 1 Measurements used to determine changes in the shape of the internal cerebral vein

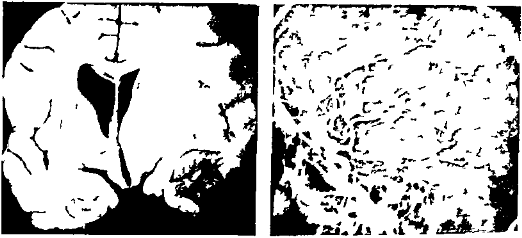
earliest and most markedly by masses within the thalamus, the vessels which lie further from the thalamus will show less marked displacements, and at a later stage For example, since the internal cerebral vein lies above and medial to the thalamus, it would be expected to be displaced upwards and across the midline in the anteroposterior view by a mass in the thalamic region Because this vein lies close to the thalamus, some displacement may be caused by relatively small thalamic masses In contrast, the pericallosal artery lies considerably further away from the thalamus and it is therefore not usually displaced until the thalamic mass is relatively large

Because tumors close to the internal cerebral vein may cause local deformity or changes in its curve a method was devised to attempt to detect early changes by means of objective measurements (Fig 1) The lowest point on the internal cerebral vein anteriorly is joined to the lowest point on the vein of Galen (AB) The length of this line was measured A line was then drawn at 90° to the midpoint (a) on this AB line, to pass through the internal cerebral vein at point C The length of this line (b) was measured Lines CA and CB were joined and the distances, (c) and (d), from their midpoints to the internal cerebral vein were measured When the curve of the internal cerebral vein is symmetrical (c) is a little larger than (d) An increased curvature of the anterior part of the vein is reflected in an increased (c) and an increased curve of the posterior part of the vein is shown by an increase in (d) Conversely flattening of the vein is shown by reduction of the measurements of lines (b), (c) and (d)

These measurements were made in 50 patients who had bilateral carotid arteriograms and where no abnormality was demonstrated The two internal cerebral veins were measured in this way and also superimposed in every case to demonstrate asymmetry of the veins on the two sides Only 7 of the 50 bilateral angiograms showed asymmetry of the two veins but even these cases showed no asymmetry of the internal cerebral veins posterior to a point 1 cm behind the presumed position of the foramen of Monro Eleven sides showed a false venous angle The average measurements in this normal group were (a) = 3 9 cm (b) = 0 9 cm, (c) = 0 2 cm and (d) = 0 03 cm

All of the cases investigated in this series had films taken with a Fairchild simultaneous bi plane roll film changer with the exception of one case

In 42 cases the position of the tumor was confirmed by an air study in 19 cases abnormal vessels were seen and an autopsy was performed in 9 cases



a b

Fig 2 a) Autopsy specimen showing outward rotation of the lower part of the insula by a thalamic space-occupying lesion The vessels which lie on the surface of the insula in its lower aspect will appear elevated b) Elevation of the middle cerebral vessels by a pure thalamic tumor

Results

A tumor involving the thalamus, and no other part of the brain, is virtually never seen, but the 19 cases included in this group were considered as fairly pure thalamic masses

Arterial phase In pure thalamic tumors, the following findings were most frequently present

In the *lateral projection* there may be elevation of the middle cerebral artery This upward displacement was seen in 10 cases and it seemed to be due to a rotation of the insula which results in elevation of the sylvian fissure (Fig 2a) The sylvian fissure then carries up with it the middle cerebral branches This may cause a thalamic lesion to be mistakenly called temporal in location Fig 2b represents an example of elevation of the middle cerebral vessels due to a pure thalamic tumor

Downward displacement of the anterior choroidal artery posterior to the cisternal portion of the vessel was seen in 6 of the cases Sometimes the anterior choroidal artery was seen to extend posteriorly for quite a distance where it was actually seen outlining the posterior aspect of the enlarged thalamus (Fig 3a) In addition the vessel was sometimes displaced laterally, or was larger than normal, or had a longer course than usual The lateral posterior choroidal artery when visible, may be seen to describe a wide arc around the enlarged thalamus but this is only rarely encountered in a carotid angiogram, none of our cases showed this Vertebral angiography would be required to show this vessel and it is felt by the authors that this additional examination is not justifiable in thalamic tumors



Fig 3 a) Elongation depression and stretching of the posterior portion of the anterior choroidal artery which forms a curve around the lower aspect of the tumor b) Widening of the space between the pericallosal and middle cerebral vessels on the side of a thalamic tumor The change is obvious when the tumor side is compared with the normal side in a cross compression film

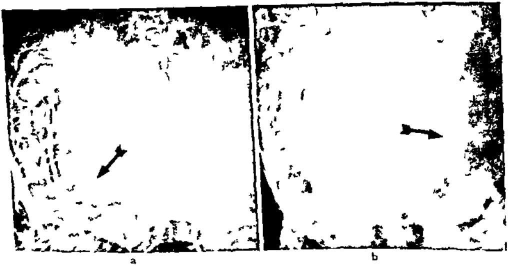
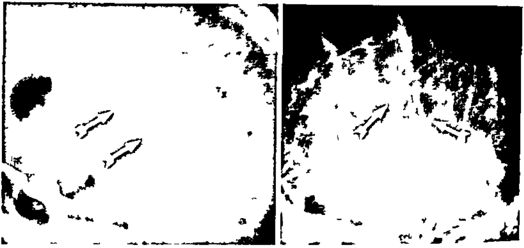


Fig 4 a) Lateral displacement and stretching of the lenticulostriate arteries by a mass in the thalamus b) Lateral displacement of the left posterior cerebral artery by a left thalamic mass growing down the left side of the brain stem (right retrograde brachial injection)

In the *frontal projection* there may be widening of the space between the pericallosal and the middle cerebral arteries due to a combination of lateral displacement of the vessels over the insula and slight displacement of the pericallosal artery across the midline (Fig 3b) Lateral displacement of the middle cerebral artery was seen in 14 cases and the pericallosal artery was displaced across the midline in 10 instances In some cases the distance from the branches of the middle cerebral artery over the insula to the inner table of the



a b

Fig 5 a) Elevation and straightening of the anterior part of the internal cerebral vein by a thalamic tumor which drained into the internal cerebral vein causing marked enlargement b) G o.s compression film showing both thalamostriate veins The one on the side of the thalamic tumor is elevated

skull may be reduced only slightly so that the change may only become apparent by comparison with the opposite side Normally, the configuration of the pericallosal and middle cerebral arteries is fairly symmetrical when the right side is compared with the left in a non rotated frontal film

The anterior choroidal artery may be displaced laterally and the lenticulostriate arteries may be displaced downwards and laterally with stretching of the normal S shaped curve, as seen in the a p view (Fig 4a)

The posterior cerebral artery may be displaced downwards and, if the tumor extends into the brain stem it may also be displaced laterally (Fig 4b) Downward displacement of the posterior cerebral artery may also be due to a downward tentorial pressure cone However, when it is associated with lateral displacement it is probably due to extention of the tumor into the brain stem whereas if it is due to herniation it is usually displaced medially and downwards

Venous phase The most common finding was elevation of the internal cerebral vein with displacement across the midline Fourteen cases showed displacement across the midline, and in 3 instances the internal cerebral vein was not seen in the a p views The elevation tended to be marked in the anterior portion of the vein, the height of the curve was usually increased in the posterior portion while the anterior part of the vein tended to be straightened (Fig 5a)

Elevation of the thalamostriate vein causes widening of the venous angle Eight cases were judged to be abnormal in the lateral projection, but this change was difficult to evaluate because normal cases may show considerable variation in the appearance of the venous angle Some of the tumor cases showed irregularity of the curve at the junction of the thalamostriate and internal cerebral veins The thalamostriate vein may be displaced upwards as

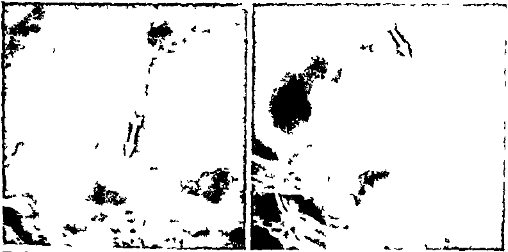


Fig 6 Depression of the posterior part of the internal cerebral vein by a mass which extends from the thalamus up into the parietal region and lateral ventricle

seen in the frontal projection, which tends to bring this vein closer to the midline or across the midline Instead of having a downward curve around the floor of the lateral ventricle the thalamostriate vein immediately ascends obliquely upwards and laterally (Fig 5b) The upward displacement of the thalamostriate vein is an expression of the elevation of the floor of the lateral ventricle which is so commonly seen in thalamic tumors demonstrated by air studies

The basal vein may be displaced downwards backwards or laterally The lateral displacement may be associated with spread of the tumor into the upper brain stem

The findings described above are essentially those found in thalamic tumors However it should always be kept in mind that the degree of displacement of the vessels is dependent on the size of the mass and on the presence or absence of extension of the tumor into the adjacent structures When tumors grow from the thalamus into other parts of the brain they may extend beyond the vessels which lie close to the thalamus and in this case the displacement tends to be reversed Since the vessel is then surrounded by tumor it may become narrowed, irregular or it may not be filled with the contrast medium For example, a tumor in the anterior part of the thalamus may cause elevation and forward displacement of the thalamostriate vein but if it grows into the frontal lobe the thalamostriate vein tends to be displaced downwards and backwards, and it may then show irregularity narrowing or non filling Five cases of ... thalamic tumor were investigated and two of these showed downward and posterior displacement of the thalamostriate vein and the anterior part of the internal cerebral vein Two other cases presumably with larger thala

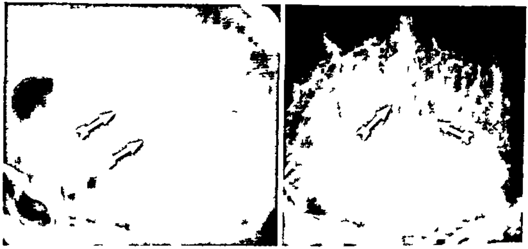


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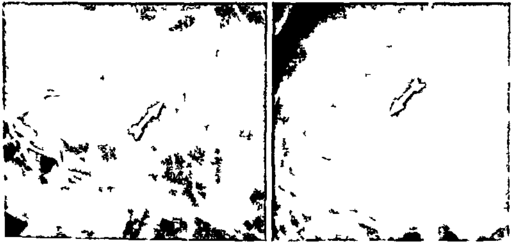


Fig 8 a) A local indentation in the inferior aspect of the internal cerebral vein caused by a pinealoma b) Enlargement of th lateral ventricles causing a corresponding change in the size and shape of the thalamostriate vein in the a p view

The 10 temporo-thalamic tumors investigated in this series involved the temporal lobe and the thalamus and the exact displacement of the lenticulo-striate and anterior choroidal arteries seemed to depend on the relative amounts of tumor in the thalamus and in the temporal lobe Temporal tumors may cause upward and medial displacement of the thalamostriate vein as seen in the frontal projection, and opening of the venous angle which usually indicate deep extension They could also displace the basilar vein downwards but tended to push it medially rather than laterally as thalamic tumors usually do

The 3 hypothalamic tumors investigated showed findings which were difficult to analyze and it appeared that these tumors were best differentiated by means of an air study One thalamic tumor extending into the brain stem was investigated by retrograde brachial arteriography and the posterior cerebral artery on the side of the tumor was shown to be displaced laterally as it passed around the brain stem (Fig 4b) Three of the 4 cases involving the septum pellucidum showed depression of the internal cerebral vein When the tumor was asymmetrical the vein was displaced from the midline In one case where there was a large tumor extending into the body of one lateral ventricle the internal cerebral vein was displaced downwards throughout its course and it was also displaced 1 cm across the midline the thalamostriate vein was obscured in the a p view by tumor vessels However this vessel if seen should be stretched laterally around the large lateral ventricle containing the tumor

In the 2 cases of colloid cysts of the third ventricle that have been investigated by angiography there was depression of the posterior two-third of the internal



Fig 7 Elevation and lateral displacement of the anterior end of the internal cerebral vein by a colloid cyst of the third ventricle

components showed slight elevation of the anterior end of the internal cerebral and the thalamostriate veins Four of these five cases showed displacement of the anterior cerebral artery across the midline and the displacement was most *marked in the more anterior part of the vessel*

Tumors which extend from the thalamus into, or which arise deeply from, the parietal lobe may cause downward displacement and flattening of the internal cerebral vein instead of simple elevation Initially when most of the tumor is in the thalamus the internal cerebral vein may be elevated but if a large component of the tumor grows up above the vein the vessel may then be displaced downwards (Fig 6) Of the 6 parieto-thalamic tumors in this series two cases showed elevation of the internal cerebral vein when the templates of WOLF et coll and of LAINE et coll were applied Two other cases showed depression of the vein when measured by WOLF s template but only one of these showed depression when LAINE s measurement of the position of the foramen of Monro was used

Deep temporal lobe tumors or thalamic tumors which invade the posterior temporal region may be difficult to differentiate The upward displacement of the middle cerebral branches seen in the lateral view in thalamic tumors should not be confused with primary temporal masses In the case of a temporal lobe tumor there is medial displacement of the branches of the middle cerebral artery as seen in the frontal projection, whereas in the thalamic tumors the vessels are displaced laterally The anterior choroidal artery is usually displaced medially in temporal tumors Sometimes the anterior choroidal is displaced upwards if the tumor arises in the inferior temporal gyri

right and left sides is of help in evaluating the relative positions of the internal cerebral veins Normally, the internal cerebral veins are fairly symmetrical in position although they may be slightly different in configuration at their anterior ends Even though they are quite close together, it is possible for a deep tumor to elevate only one vein All three patients with pure thalamic masses that had bilateral angiograms showed an asymmetry of the veins when one side was compared with the other (Fig 9)

In thalamic tumors there may be increased curvature of the posterior part of the internal cerebral vein in relation to the anterior part as shown by an increase in the line (d) and a decrease in the line (c) In 4 of the thalamic tumors (d) was larger than (c) and this was never seen in the normal cases A similar change was sometimes seen in fronto thalamic, parieto thalamic and temporo thalamic tumors It was also seen in tumors situated below but close to, the posterior part of the internal cerebral vein, including tumors in the pineal region and a tumor occupying most of the third ventricle The curve of the internal cerebral vein was reduced or even reversed by tumors arising immediately above the vein in the septum pellucidum or within the lateral ventricles This was reflected in reduction of the measurement lines (b), (c), and (d)

SUMMARY

The angiographic changes caused by 19 tumors in the thalamus were studied and compared with 40 tumors adjacent to the thalamus All of the cases studied showed definite abnormalities in the angiogram and in almost every case the mass could be localized quite accurately provided the vessels in the region were clearly demonstrated Some criteria for the differentiation of the various tumors in this region are suggested

ZUSAMMENFASSUNG

In 19 Fallen mit Tumoren im Thalamus wurden die angiographischen Veranderungen studiert und mit 40 Fallen von Tumoren die an den Thalamus angrenzen verglichen In allen Fallen waren ausgeprägte Veranderungen im Angiogramm sichtbar und in fast allen Fallen konnten die Veranderungen unter der Voraussetzung dass die Gefasse deutlich zur Darstellung kamen ziemlich genau lokalisiert werden Einige Kriterien zur Differenzierung verschiedener Tumore in dieser Region werden vorgeschlagen

RÉSUMÉ

Les auteurs ont etudié les signes angiographiques donnes par 19 tumeurs du thalamus et les ont compares avec ceux de 40 tumeurs adjacents au thalamus Tous les cas étudiés présentent de nettes anomalies angiographiques et dans presque tous les cas à condition que les vaisseaux de la région soient clairement visibles la tumeur a pu etre localisée exactement Les auteurs proposent des criteres pour différencier les diverses tumeurs de cette région

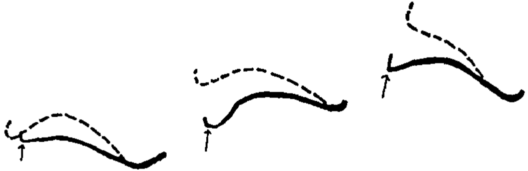


Fig 9 Drawings of the two internal cerebral veins in cases of thalamic tumors where bilateral carotid arteriograms were obtained The discontinuous lines represent the vein on the side of the tumor

cerebral vein with an elevation of the anterior third as it reached the foramen of Monro In the frontal projection the thalamostriate vein in its proximal portion actually described a curve concave medially and downwards around the cyst (Fig 7) Depression of the internal cerebral vein is seen when there is a block at the foramen of Monro with collapse of the third ventricle and enlargement of the lateral ventricles The appearance of a block at the foramen of Monro due to a tumor of the septum pellucidum is somewhat similar to that caused by a colloid cyst of the third ventricle except that the colloid cyst causes some elevation of the anterior end of the internal cerebral vein while a tumor of the septum pellucidum causes depression of the whole length of the vein Tumors situated in the posterior portion of the third ventricle such as pinealomas, produce elevation of only the posterior portion of the internal cerebral vein and sometimes only a localized narrowing from its lower aspect (Fig 8a)

Elevation of the internal cerebral vein may be produced by tumors within the third ventricle In masses which are situated in the center of the third ventricle there may be an irregular elevation, or, if the tumor is cystic, a smooth elevation which could at times be confused with a thalamic mass However in these cases, the thalamostriate vein is not displaced upwards and medially in the a p view, but it is increased in its curvature in the frontal projection and shows a typical appearance of ventricular dilatation (Fig 8b)

Ventricular dilatation may cause some of the signs seen in thalamic tumors such as lateral displacement of the middle cerebral vessels as seen in the frontal projection, elevation of the middle cerebral group in the lateral projection due to enlargement of the temporal horn lateral and downward displacement of the lenticulostriate arteries However, ventricular dilatation usually produces slight flattening of the curve of the internal cerebral vein without elevation and, in addition, in the frontal projection the thalamostriate vein would describe a typical broad curve concave upward

It should be stressed that bilateral angiography may make a diagnosis obvious when it is difficult with unilateral angiography Superimposition of the

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SIMULTANE MERSCHICHTIGE TOMOGRAPHIE UND IHRE ANWENDUNG IN DER GEHIRNANGIOGRAPHIE

von

G. ROSADINI und P. ROCCA

Wie bereits bekannt, erlaubt die simultane, mehrschichtige Tomographie mittels Anwendung einer besonderen Kassette die Aufnahme mehrerer Tomogramme. Die Anzahl und der Fokus-Film-Abstand kann von dem Untersucher beliebig bestimmt werden, indem er in diese Kassette die gewünschte Anzahl von Filmen einlegt (von 1 bis 5) und zwischen die einzelnen Filme Einlagen beliebiger Stärke einführt (0,5 bis 1 cm). Auf diese Weise kann man mit einer einzigen Handhabung die verschiedenen technischen Handgriffe vereinfachen, die in der üblich angewandten tomographischen Technik zur Aufnahme einzelner Tomogramme nötig sind, und dabei die Arbeitszeit wesentlich verkürzen. Ein zweiter und nicht unbedeutender Vorteil dieser Methode besteht darin, dass das Objekt nur ein einziges Mal belichtet wird, während bei Anwendung der Standardmethode so viele Exponierungen nötig sind, wie die Anzahl der zu prüfenden Schichten erfordert. Zweifellos jedoch liegt der bedeutendste Vorteil dieser Methode in der treuen Wiedergabe, die dadurch ermöglicht wird. Während in die Pausen zwischen den einzelnen Aufnahmen bei Anwendung der Standardtomographie sich leicht Veränderungen in der Lage des Patienten ergeben, die durch unwillkürliche Bewegungen oder

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des Atlas. Man bedient sich dabei der percutanen posterioren Methode, die von uns bereits früher beschrieben worden ist und in unserem Laboratorium Anwendung findet.

In dieser Lage werden die Aufnahmen zuerst in seitlicher und dann in postero-anteriorer Projektion durchgeführt, während man die Nadel unverändert in loco lässt und den Patienten langsam bis zur Rückenlage dreht. Selbstverständlich erleichtert das Vorhandensein eines Craniotomographen die Ausführung der Untersuchungen.

Die Quantität des anzuwendenden Kontrastmittels ist dieselbe, die für eine Standarduntersuchung benötigt wird — 8 bis 10 ml für das Carotis — und 3 bis 4 ml für das Vertebralisgebiet. Auf diese Art erhält man fünf Tomogramme von 1 cm Schichtdicke, die sich bei unseren Forschungen als am günstigsten für diese Art von Untersuchungen erwiesen hat.

Aus Untersuchungen an praktischen Fällen und auf Grund der oben angeführten Erläuterungen scheint es möglich, folgende Schlussfolgerungen zu ziehen.

1. Die simultane mehrschichtige Tomographie ermöglicht die Darstellung der verschiedenen Schichten der endokraniischen Gefässgebiete.

2. Die Untersuchung verursacht kein besonderes Risiko für den Patienten, da sie sofort im Anschluss an die angiograpische Standarduntersuchung vorgenommen wird und keine grössere Menge an Kontrastmitteln und keine stärkere Bestrahlung beansprucht als die Standarduntersuchung.

Unserer Ansicht nach, und auf Grund der Angaben die uns bisher zu Verfügung stehen, existieren keine genaueren Berichte über die Angiotomographie. Wie bei jeder anderen Tomographie, wird der untersuchende Arzt jeweils auf Grund der Resultate der angiographischen Standarduntersuchung auf dieses neue diagnostische Hilfsmittel der Angiotomographie zurückkommen können, und dies so oft als es ihm nötig erscheint, um grössere Klarheit im Bild zu erhalten, und wenn es ihm hilft, die pathologischen vaskulären Elemente in ihren verschiedenen Schichten darzustellen und von anderen Strukturen zu trennen.

ZUSAMMENFASSUNG

Die Autoren beschreiben die Vorzüge der simultanen mehrschichtigen Tomographie und deren Anwendung für die Arteriographie der Carotis und Vertebralis. Ein Excursionswinkel von 35 Grad produziert Schnitte von einem Zentimeter und dies hat sich für die Untersuchung abnormaler Gefässe als nützlich erwiesen.

SUMMARY

The authors discuss the advantages of simultaneous multilayer tomography and its application in carotid and vertebral cerebral arteriography. An angle of swing of 35 produces one centimetre cuts and these have proved very suitable for the examination of pathologic vessels.

Atmung hervorgerufen werden konnen, und in den verschiedenen Filmen dadurch nicht einheitliche Untersuchungsbedingungen vorliegen, sind diese Fehlerquellen bei Anwendung der simultanen mehrschichtigen Tomographie absolut ausgeschlossen Die Anwendung dieser Technik hat sich im tomographischen Studium des Skeletts, der Gallenblase und Gallengange nutzlich erwiesen

Abgesehen von den bereits erwahnten, vielen, unbestreitbaren Vorteilen im Vergleich mit der Standardmethode, hat sich diese Technik beim tomographischen Studium von dynamischen Situationen als einzigartig und unersetzlich erwiesen Bei der Rontgenuntersuchung von Gegenden, die durch ein bewegliches Kontrastmittel verdunkelt werden, z B bei Bronchographie und Angiographie, wurde keine technische Vorsicht (absoluter Ruhezustand des Patienten, unbedingte Apnoe, rascheste Durchführung) genugen, um mittels Anwendung der konventionellen Technik eine einwandfreie tomographische Untersuchung zu gewahrleisten Es ware unbedingt notig, sich eines Kontrastmittels zu bedienen, und dies ebenso viele Male wie bei der Anzahl von Schichten zur Untersuchung vorgesehen ist, was naturlich paradox und unmoglich ist

Die Tatsache, dass die tomographischen Aufnahmen gleichzeitig durchgeführt werden konnen, lost spielend alle diese Schwierigkeiten und gestattet die gleichzeitige Aufnahme von Tomogrammen innerhalb einer kurzen Zeitspanne

Um mit dieser Methode einen nutzlichen Beitrag zu den angiographischen Untersuchungen in der Neurorontgenologie zu leisten, haben wir uns seiner zeit dafür interessiert, eine Technik fur zerebrale Angiotomographie zu finden Es scheint uns nutzlich hier die wichtigsten technischen Daten der Ergebnisse unserer ersten Untersuchungen anzuführen, die wir bereits in einem fruheren Artikel behandelt haben 80 bis 85 kV in der lateralen und 90 bis 95 kV in der antero posterioren Projektion, 32 × 1 8 = 58 mAs, tomographischer Aufnahmewinkel 35° Focus Film Abstand 105 cm

Die Technik bei Arterien Injektionen ist naturlich verschieden je nachdem ob sich die Untersuchung auf das Carotis oder auf das Vertebralisgebiet bezieht, und es muss bei der Handhabung berucksichtigt werden, dass Rontgengerat und Filmkassette miteinander verbunden sind Im ersteren Falle sticht man, wie es die Überlieferung lehrt, in die Carotis wobei der Patient auf Rukken liegt und den Kopf in leicht gespannter Lage halt, und man führt in dieser Stellung die antero posteriore Projektion des ersten Angiogrammes und der frontalen Tomographie durch Dann dreht man den Kopf um 90° und führt wahrend man die Kanule unverandert lasst, die gleichen Standard und tomographischen Aufnahmen in seitlicher Projektion durch

Bei einer Untersuchung des A Vertebralisgebietes legt man den Patienten auf die Seite, unterstutzt den Kopf so, dass die Lage des Rumpfes unverandert bleibt, und punktiert die A vertebralis in ihrer horizontalen Strecke, oberhalb

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BLOOD SUPPLY IN MENINGIOMA OF THE FALX

by

MAURI ROUKKULA and GEORG FREDRIK SALTZMAN

Most intracranial meningiomas receive their blood supply through both the external and the internal carotid arteries, the share borne by each vessel varying in the individual case. Detailed information on this point can only be obtained by injecting the contrast medium into each of the arteries separately.

It has long been considered that unlike other meningiomas those originating in the falx cerebri are supplied solely through the internal carotid artery. This view has also been advanced in several fairly recent publications. HAAR and TIWISINA, for instance, found no evidence to indicate that falx meningiomas are supplied via the external carotid artery, and in their opinion this is of decisive differential diagnostic significance in distinguishing between these meningiomas and those of the parasagittal convexity. They based their assumption on angiographies in which the contrast medium had been injected into the common carotid artery. KAUTZKY and ZULCH (1955) came to the same conclusion.

Investigations reported from Serafimerlasarettet (ANDERSON 1952, LINDGREN 1954) have demonstrated, however, that some of these meningiomas are supplied by branches from both the internal and the external carotid arteries. These authors described cases in which the internal carotid artery supplied the peripheral parts of the tumour while its centre received its blood from the

RÉSUMÉ

Les auteurs rappelent les avantages de la tomographie multiple simultanee et décrivent son application a l angiographie cérébrale carotidienne et vertébrale L angle de balayage de 35 donne une épaisseur de coupe d un centimètre qui facilite l étude des vaisseaux pathologiques

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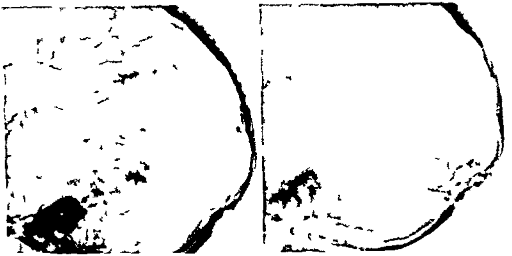


Fig 2 Meningioma originating in the hindmost portion of the falx Blood vessels in the anterior portion of the tumour visible after injection of medium into the internal carotid artery (left) After injection into the common carotid artery vessels in the posterior portion as well filled through a greatly widened occipital branch of the external carotid artery (right)

external carotid artery Later investigators (LECUIRE, CORRADI & COURJON 1957) encountered among 16 cases of falx meningioma one case in which the anterior portion of the tumour was supplied by branches from the external carotid artery BERNASCONI and CASSINARI also described two cases of falx meningioma in which the tumour to some extent at least received its blood supply via the external carotid artery

Since we began the practice at Serafimerlasarettet of consistently injecting contrast medium into the internal and external carotid arteries separately with a view to throwing more light on the paths by which the meningiomas receive their blood we have been encountering an increasing number of cases in which meningiomas arising in the falx cerebri have also appeared to be supplied from a double source It therefore seemed of interest to review the material from the past ten years

Material

This material comprising 18 cases includes all the falx meningiomas in which carotid angiography was performed and yielded qualitatively satisfactory results All patients underwent operation and the diagnosis of meningioma was verified histologically in every instance It is of course sometimes difficult for a surgeon to determine the exact site at which a meningioma has originated but the material presented here contains only those cases in which it was obvious at operation that the tumour had arisen in the falx

The material may be divided into three groups with 6 cases in each group



Fig 1 Meningioma originating in the mid portion of the falx Blood vessels at the periphery of the tumour visible after injection of medium into the internal carotid artery Blood vessels at the centre lower views, became visible after injection into the external carotid artery

into both the internal and external carotid arteries Contrast filling of a large part of the tumour via branches from the internal carotid artery was obtained in one of these 3 cases Injection of contrast medium into the external carotid in this case revealed a pathologically widened middle meningeal artery Although neither pathologic tumour vessels nor filling of any part of the tumour were observed it seemed logical to assume that the widened vessel took part in supplying blood to the tumour The middle meningeal artery was pathologically widened in another case as well in this case, however, neither injection into the internal nor injection into the external carotid artery succeeded in demonstrating any pathologic vessels in the tumour area or in showing contrast filling of the tumour In the third case in spite of the homogeneous structure of the tumour only its periphery was filled this suggested that its centre received its blood supply through the external carotid artery (Fig 3), although this could not be verified, as no pathologic vessels were visible nor was any filling of the tumour obtained when contrast medium was injected into the external carotid artery

3 *Cases in which contribution of the external carotid artery could not be assessed* In none of these 6 cases was contrast medium injected into the external carotid artery In 2 instances no pathologic vessels were demonstrated in the tumour area nor contrast filling of the tumour obtained at angiographies with injection into the internal carotid artery, while in the other 4 cases the greater part of the tumour at least was outlined with this technique

Discussion

In a material consisting of 18 meningiomas of the falx cerebri we have demonstrated with certainty that six of the tumours received blood from both the external and the internal carotid artery while such a double blood supply was assessed as probable in a further six cases Angiography with injection into the external carotid artery was not carried out in the remaining six cases It should be specially stressed that several of the angiographies in this material particularly among those cases in which no pathologic vessels were demonstrated, were performed in the conventional manner with manual changing of the cassettes Rapid serial angiography must be used to prove beyond doubt whether pathologic blood vessels are present or not

These observations suggest that contrary to earlier opinions falx meningiomas often receive their blood via both the external and internal carotid arteries It is not unlikely that the distribution of blood to these tumours largely follows the same or similar rules to those applying in all other types of meningioma In any event there seems to be no justification for asserting that falx meningiomas are always or usually supplied solely through the internal carotid artery, a viewpoint which has previously been considered to have decisive



Fig 3 Internal carotid angiography in meningioma of the falx cerebri Blood vessel are visible only at the periphery of the tumour As the tumour was histologically homogeneous its centre was probably supplied through the external carotid artery although no tumour vessels filled after injection of medium into that artery

1 *Cases in which contribution of the external carotid artery to the blood supply of the tumour was confirmed* In 5 of these 6 cases, pathologic blood vessels in the tumour were demonstrated at angiographies in which the contrast medium had been injected into the internal and external carotid arteries separately In the sixth case, such vessels were shown only after injection of the medium into the external carotid The external carotid artery contributed blood to the meningioma through branches of the middle meningeal artery in 4 of the 6 cases and through branches of the occipital artery in 2 cases In the 4 cases in which branches from the middle meningeal artery took part in the blood supply of the tumour these branches carried blood to its centre while branches from the internal carotid supplied its peripheral areas (Fig 1) In both the cases in which the tumour received blood from the occipital artery the tumour had originated in the hindmost part of the border of the falx, near the tentorium the anterior portion of these two tumours was supplied through the internal carotid artery and the posterior portion through the occipital artery (Fig 2)

2 *Cases in which the external carotid artery was a probable contributor* In 3 of these 6 cases angiography with injection only into the internal carotid artery was performed in all 3 instances only a part of the tumour could be roentgenographically demonstrated despite the fact that the tumour tissue was homogeneous throughout In the other 3 cases the contrast medium was injected

FROM THE NEURORADIOLOGIC DEPARTMENT (DIRECTOR PROF G RUGGIERO) OF OSPEDALE MAGGIORE BOLOGNA ITALY, AND THE NEURORADIOLOGIC (DIRECTOR PROF H FISCHGOLD) AND NEUROSURGICAL (DIRECTOR PROF M DAVID) DEPARTMENTS OF HOPITAL DE LA PITIE, PARIS FRANCE.

ARTERIOGRAPHY OF THE EXTERNAL CAROTID ARTERY

by

G RUGGIERO A CALABRO J METZGER, and J SIMON

The aim of this communication is to present an account of experiences with the technique and diagnostic application of selective puncture of the external carotid artery This approach was described by RUGGIERO & JAY in 1958 and had then been successful in 19 of the 21 cases reported The material had in 1960 increased to 58 arteriographies four of which had been failures

The method according to private communications has since then been employed at other centres and there been successful in about 80 % of cases It would therefore appear to have gained a firm place in neuroradiologic techniques

Arteriography of the external carotid artery will permit differentiation to be made between intra and extra cerebral tumours of the convexity particularly in cases of meningioma in which the nature as well as the situation of the tumour may be defined (Figs 1 to 5) Arteriography of the common carotid artery may in such cases often yield the same information as arteriography of the



a b

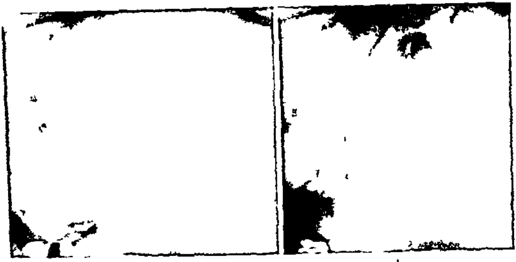


c

Fig 1 Frontal meningioma a) and b) Arteriography of the internal carotid artery Frontal tumour with atypical vascularization the tortuosity and the irregular calibre of the newly formed vessels suggest a malignant lesion c) Arteriography of the external carotid artery shows that the tumour is a meningioma mainly supplied by the dilated frontal branch of the middle meningeal artery



Fig 2 (to the left) Meningioma of the convexity The small tumour is supplied exclusively by the dilated posterior branch of the middle meningeal artery Arteriography of the internal carotid had revealed the presence of an avascular tumour



a b



c

Fig 3 Meningioma within the falx and on the dura of the convexity (a) Arteriography of the internal carotid artery demonstrates an avascular parasagittal tumour (b) and (c) The nature and the origin of the lesion were demonstrated by arteriography of the external carotid artery

external carotid artery but the latter method may sometimes disclose the participation of the external carotid artery in the supply of the tumour and thus indicate its extra cerebral site (Fig 4) In the case shown in Fig 5 only arteriography of the external carotid artery revealed a meningioma of the tentorium It must be borne in mind however that not all extra cerebral tumours are meningiomas (Fig 6) Furthermore a negative finding may often be of considerable value (Fig 7

The method will permit a demonstration of the participation of the external carotid artery in cases of arteriovenous malformation and afford information regarding any difficulties likely to be encountered at operation (Fig 8



a b

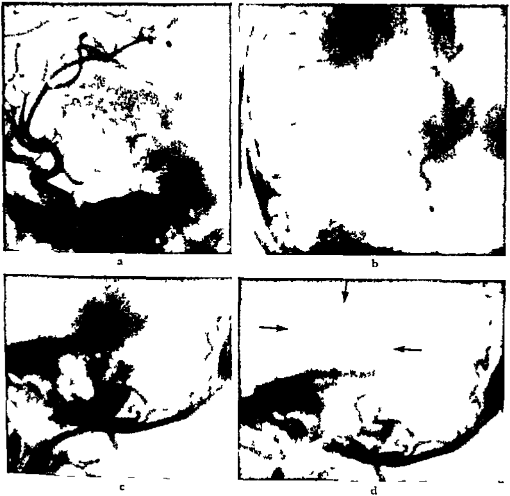


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Fig 4 Parietal meningioma of the convexity Arteriography of the common carotid artery shows the site of the lesion (a) and possibly a zone of diffuse vascularity in the venous phase (b) (arrows) Arteriography of the external carotid artery (c) shows the tumour stained by contrast medium and thus well outlined

Arteriography of the external carotid artery will generally establish the differential diagnosis between extra and intra dural haematomas (Figs 9 to 11)

LINDGREN emphasized the importance of lacerations of the branches of the external carotid artery with resultant accumulation of contrast media outside the vessels, and HIRSCH described deformities of the meningeal vessels in extradural haematoma The latter observed a case in which, apart from the presence of a typical deformity of the middle meningeal artery, numerous lacerations of the arteries and veins had resulted in the formation of a traumatic arteriovenous fistula (Fig 11)





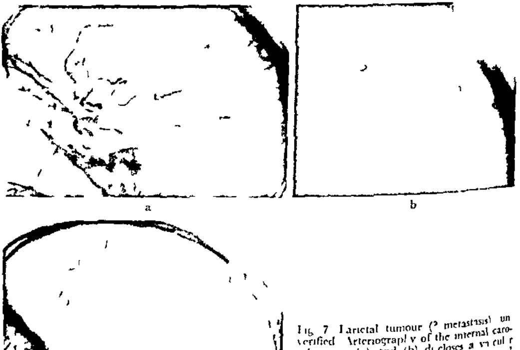
e

Fig 5 Men ngio na f the tentor um ith supra tentorial ext ns o on th ght s de Arteriography of the comm carot d artery (a) and (b) shows an expanding a a cu la les on in the posterior temporo-basal a a A teriography of the external carot d artery is pathognomonic (c d e) and demonstrate the m ning oma n an early arterial pha e and its origin (Ve teb al arte ography was not undertaken because of the good demonst at on of th posterior cerebral artery by internal carotid a ter ography)



a b

Fig 6 Parietal osteolytic metastases from carcinoma of the breast a) Arteriography of the internal carotid demonstrates relatively slight intracranial extension of the lesion No newly formed blood vessels evident b) Arteriography of the external carotid artery demonstrates the full extent of the lesion and its extremely rich vascular nature

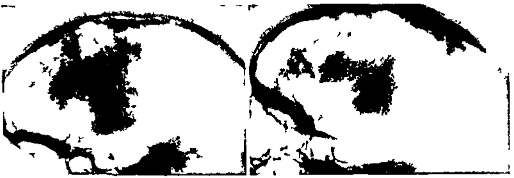


a b



c

Fig 7 Parietal tumour (? metastasis) unverified Arteriography of the internal carotid artery (a) and (b) discloses a vascular tumour which begins to appear in the arterial phase and is clearly defined in the capillary phase Arteriography of the external carotid artery (c) being negative indicates that the lesion is intra cerebral



a b

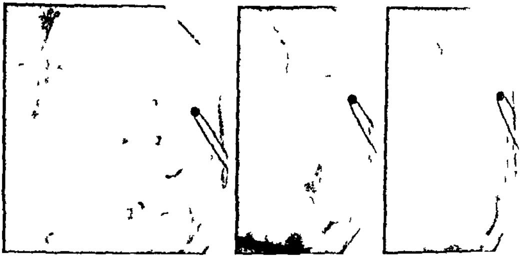
Fig 8 Arteriovenous aneurysm a) Internal carotid arteriography The contrast medium immediately enters the lesion which occupies a considerable part of the hemisphere b) Arteriography of the external carotid artery The aneurysm is also well demonstrated especially in the frontal and parietal regions anteriorly

Another advantage of this technique lies in the fact that repeated injections of contrast *medium may be made with complete confidence* This assumes particular *importance in elderly subjects who form the majority of meningioma* cases, and in whom because of cerebral arteriosclerosis, arteriography of the internal carotid artery must often be undertaken with caution For this reason we initially perform arteriography of the external carotid artery in all cases of possible meningioma this often renders all other types of examination unnecessary



a b

Fig 9 Accumulation of contrast medium around the middle meningeal artery in a case [illegible] haematoma



a b c

Fig 10 Extradural haematoma a) Arteriography of the internal carotid artery Typical appearances of an extracerebral haematoma b) and c) Arteriography of the external carotid artery demon trates normal appearances of the superficial temporal artery and medial displacement and stretching of the middle meningeal artery signs indicating an extradural lesion



a b

Fig 11 Extradural haematoma The presence of numerous arterial and venous lacerat ons has pro duced traumatic arteriovenous fistulae

SUMMARY

Experiences with percutaneous arteriography of the external carotid artery in a material of 58 cases are described The method has proved to be of particular value in the examination of meningioma of all extracerebral tumours extradural haematoma and of arteriovenous malformations

ZUSAMMENFASSUNG

Die Resultate von 58 Fällen von Arteriographie der Arteria carotis externa werden besprochen Die Methode ist besonders wertvoll in Fällen von Meningeom extracerebralen Tumoren extraduralen Haematomen und in arteriovenosen Missbildungen

RÉSUMÉ

Les auteurs présentent les résultats de l'artériographie percutanee de l'artere carotide externe dans une série de 58 cas Cette methode s'est montrée particulièrement utile pour l'examen des méningiomes, de toutes les tumeurs extracérébrales des hématomes extraduraux et des malformations arterio veineuses

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RADIOGRAPHIC EVALUATION OF MAJOR ARTERIES OF THE NECK BY INTRAVENOUS AORTOGRAPHY

by

JAMES H SCATLIFF and RICHARD H GREENSPAN

Until very recently the status of the extracranial arteries of the neck and mediastinum could be appraised in only two ways The first has been an indirect approach employing palpation auscultation evaluation of ocular changes, and simple radiography The second has consisted of arterial injections of contrast material by needle puncture or catheter techniques In many instances arterial delivery can be performed without complication The dangers of hemorrhage, thrombosis, and vessel dissection or perforation are always present however and are amplified in the presence of arteriosclerosis

VIALLET in 1956 and STEINBERG (1961), and others lately have suggested that intravenous administration of contrast media may be used to delineate the aortic arch and extracranial arteries The first aim of this communication is to describe how intravenous aortography can be applied as a screening procedure in the evaluation of these arteries The second is to criticize the results of the technique in a limited case series and summarize the reasons for and against its use

Presented in part at the 46th Annual RSNA Meeting in Cincinnati Ohio 1960 Supported by USPHS Grant H 5518 (CL)



Fig 1 Case 1 Upper arrow points to a partial block in the left internal carotid artery The size of the left vertebral artery may be due to possible compensatory enlargement (lower arrow)



Fig 2 Case 2 Almost complete occlusion of left internal carotid artery at upper arrow Long segment of arteriosclerotic narrowing in left common carotid artery (lower arrow)

Technique

Intravenous aortography or forward angiography may be done in several ways We have found and as indicated by ZERBI ORTIZ & WELDON (1961) that a large diameter NIH catheter in the right atrium is of considerable help when studying the vessels of the neck Trapping of contrast material in neck veins due to an inadvertent Valsalva maneuver is prevented (cf Fig 7a) Stasis of contrast material in neck veins with concealment of arteries is also sidestepped If the heart cannot be catheterized easily the NIH catheter is withdrawn and a polyetylene 280 tubing secured tightly to a 14 gauge needle is advanced to the mid arm GREENSPAN et coll (1960) A third method as recommended by STEINBERG eliminates the need if large antecubital veins are present for venotomy If polyethylene tubing or vein cannulas are used it is quite important to elevate the arm or arms before injection Postural venous obstruction and fractionation of the bolus may be reduced in this way If either of the first two methods are used automatic pressure injections may be made If a catheter is installed in the heart concurrent fluoroscopy of the head in the a p projection is useful In doing this the mandible and occiput can be superimposed exactly permitting an unobstructed view of the carotid bifurcation

The circulation time is obtained immediately before injection and Decholin (sodium dehydrocholate) has been satisfactory for this A mixture of 5 ml of this material and 50 ml of saline is used The opaque agent employed has been either Hypaque 90 % or Renografin 85 A preliminary test dose of 1 ml of the contrast medium is given The dosage schedule has been approximately 1 ml per kilo of body weight In more recent cases this figure has been revised upward and the contrast bolus has ranged between 80 and 100 ml The patient should be cautioned that an intense but transient flushing and desire to cough (cf Fig 7b) may occur immediately after the injection Serial filming is used and the automatic changer is started 5 to 6 seconds before the circulation end point and continued at a rate of 1 film per second for 14 second The prolonged filming period allows sufficient latitude for errors in circulation time as well as filming venous return in the neck

Case reports

Case 1 A 4? year old white male was admitted to the Grace New Haven Hospital after two days of dysarthria and a three week history of episodic weakness of the right upper and



Fig 3 Case 3 Bilateral internal carotid artery occlusion at the carotid bifurcation (upper arrows) Distal vessels outlined are the external carotid arteries Marked narrowing of the proximal vertebral artery is seen (lower arrow)

lower extremity He had been treated for intermittent claudication for two years during which time a lumbar sympathectomy and aortico-femoral bypass grafting had been carried out Physical examination revealed a loud bruit over the left internal carotid artery at the angle of the jaw The left carotid pulse was decreased and could not be palpated through the tonsillar floor

Intravenous aortography done in the a p projection (Fig 1) showed what appeared to be partial occlusion of the left internal carotid artery at its origin Both common carotid vessels were intact The left vertebral artery was larger than the right The left jugular vein was larger than the right

At surgery an arteriosclerotic plaque producing almost complete obstruction of the internal carotid artery was found 1 cm from the bifurcation Endarterectomy was performed with satisfactory restoration of blood flow through the vessel The patient has shown complete absence of symptoms since the surgical procedure

Case 2 A 54 year old hypertensive white female had a six week history of intermittent loss of vision in the left eye episodes of expressive aphasia and right sided weakness Two years before she had a transient episode of left hemiplegia Physical examination revealed diminished pulsation in the left common carotid artery in the neck A bruit could be heard in the same area

Intravenous aortography showed almost complete occlusion of the left internal carotid artery immediately above the carotid bifurcation (Fig 2) One hour after completion of the study the patient s speech which had been clear during the examination became slurred and a marked intensification of her right hemiparesis occurred Immediate surgery was performed and an extensive atheromatous change with marked narrowing of the lumen of the internal carotid artery above the bifurcation was found Evidence of a small apparently fresh blood clot within the lumen was present Endarterectomy and bypass grafting were deemed unwise due to the extent of narrowing and the presence of arteriosclerosis in the carotid bifurcation and distal common carotid artery

The clinical status of the patient which had developed after the intravenous aortogram has shown only moderate improvement over an eight month period



a b

Fig 4 Case 4 a) Direct carotid arteriogram Obstruction of left carotid bifurcation and left internal carotid artery (arrow) Minimal flow of contrast material in the internal carotid artery b) Intravenous aortography in right posterior oblique projection Obstruction is present in right carotid bifurcation (arrow) Left carotid bifurcation indistinct due to the overlapping spine

Case 3 A 50-year-old diabetic male was admitted to the Grace New Haven Hospital with a history of sudden left-sided seizures followed by unconsciousness Physical examination revealed left hemiparesis which cleared several days after admission Five years before the patient experienced a left cerebral vascular accident with the development of a permanent right hemiplegia No arteriographic examinations were carried out at that time and the clinical assumption was vascular thrombosis in the left internal capsule Palpation of the carotid arteries in the neck revealed strong pulsations bilaterally in both the present and past admissions

Intravenous aortography (Fig 3) showed patent common carotid arteries to the level of the bifurcations The internal carotid arteries on either side could not be demonstrated The left vertebral artery although large compared to the right appeared to be diffusely involved by intimal plaques Surgical correction was not carried out

Case 4 A 67 year-old hypertensive white male was admitted to the Grace New Haven Community Hospital for a gangrenous toe secondary to progressive vascular insufficiency of the lower extremities developing over a period of one and a half years A year prior to admission he had sustained a right cerebral vascular accident with transient left hemiparesis Physical examination revealed decreased pulsation in the left common carotid as well as a



Fig 3 Case 3 Bilateral internal carotid artery occlusion at the carotid bifurcation (upper arrows) Distal vessels outlined are the external carotid arteries Marked narrowing of the proximal vertebral artery is seen (lower arrow)

lower extremity He had been treated for intermittent claudication for two years during which time a lumbar sympathectomy and aortico-femoral bypass grafting had been carried out *Physical* examination revealed a loud bruit over the left internal carotid artery at the angle of the jaw The left carotid pulse was decreased and could not be palpated through the tonsillar floor

Intravenous aortography done in the a p projection (Fig 1) showed what appeared to be partial occlusion of the left internal carotid artery at its origin Both common carotid vessels were intact The left vertebral artery was larger than the right The left jugular vein was *larger than the right*

At surgery an arteriosclerotic plaque producing almost complete obstruction of the internal carotid artery was found 1 cm from the bifurcation Endarterectomy was performed with satisfactory restoration of blood flow through the vessel The patient has shown complete absence of symptoms since the surgical procedure

Case 2 A 54 year-old hypertensive white female had a six week history of intermittent loss of vision in the left eye episodes of expressive aphasia and right sided weakness Two years before she had a transient episode of left hemiplegia Physical examination revealed diminished pulsation in the left common carotid artery in the neck A bruit could be heard in the same area

Intravenous aortography showed almost complete occlusion of the left internal carotid artery immediately above the carotid bifurcation (Fig 2) One hour after completion of the study the patient s speech which had been clear during the examination *became* slurred and a marked intensification of her right hemiparesis occurred Immediate surgery was performed and an extensive atheromatous change with marked narrowing of the lumen of the internal carotid artery above the bifurcation was found Evidence of a small apparently fresh blood clot within the lumen was present Endarterectomy and bypass grafting were deemed unwise due to the extent of narrowing and the presence of arteriosclerosis in the *carotid bifurcation and distal common carotid artery*

The clinical status of the patient which had developed after the intravenous aortogram has shown only moderate improvement over an eight month period

Intravenous aortography showed disparity in the size of the carotid vessels the entire left carotid tree in the neck being approximately one half the caliber of the right (Fig 5a) No obstruction was identified Minimal irregularities in the outline of the contrast material in the left carotid artery and internal carotid artery indicated the presence of arteriosclerosis The vertebral arteries were of equal size The left jugular vein was moderately reduced in size compared to the right (Fig 5b) A clinical diagnosis of thrombosis of the middle cerebral artery probably in the lenticulostriate vessels was made as well as of carotid insufficiency secondary to arteriosclerosis Questionable congenital hypoplasia of the left carotid tree in view of the findings in the intravenous aortogram was suggested

Discussion

These five case histories provide a cross sectional view of the radiologic information which may be derived from intravenous aortography when used specifically for subcranial arterial diagnosis The intravenous aortogram served as an immediate guide for surgical therapy in Cases 1 and 2 The documentation of bilateral internal carotid artery obstruction and a single arteriosclerotic vertebral artery in Case 3, obviated further and possibly dangerous diagnostic efforts Case 4 is of interest in that prominent common carotid narrowing was found in the presence of vigorous carotid pulsation Again an entire survey of the apparently uninvolved carotid system in the neck on the right could be made without resorting to direct arterial methods The discovery of a small caliber left carotid tree in Case 5 emphasized the need for a retrograde approach through the brachial or femoral arteries, rather than direct injection if further studies were to be carried out for demonstrating the cerebral vessels on the left side

The majority of cases studied with the intravenous method resemble Cases 1 through 4 in that historical or previous angiographic evidence suggested that multiple areas of arteriosclerotic disease were present The extensive autopsy studies of carotid arteries by FISHER in 1954 and a similar recent analysis of the entire extracranial arterial system by MARTIN et coll (1960) indicate that several vessels are frequently involved by arteriosclerotic disease in the same case The likelihood of silent multiple vessel involvement in older age groups in the longstanding diabetic, or in younger subjects with abnormal cholesterol metabolism underlines the need for total angiographic studies of neck and cerebral vessels as a prelude to possible surgical correction

In several clinics this has taken the form of retrograde brachial or femoral artery catheterizations with contrast material delivery in the aortic arch or great vessels Attempts have also been made to outline the carotid and vertebral arteries on one side by retrograde injection of the common carotid artery TINDALL & CUPP (1961) At present these techniques as well as direct carotid arteriography when successful produce optimal filling of these vessels Again, however injection or catheterization particularly in severely arteriosclerotic vessels may create an undue hazard

The complications seen with the intravenous method have been minor



a b

Fig 5 Case 5 a) Left common carotid artery of small caliber with minimal arteriosclerotic irregularities (arrow) b) Prominent jugular return of contrast material on the right (arrow) and limited return on the left is probably due to physiologic variation in cerebral venous drainage

continuous thrill over this vessel The right common artery exhibited a normal pulsation The peroral palpation of the internal carotid arteries was strong on the right and absent on the left

A direct carotid arteriogram on the left showed marked stenosis of the carotid bifurcation with almost complete blockage of the internal carotid artery and marked reduction of flow through this vessel (Fig 4a)

Intravenous aortography was carried out in the right posterior oblique position to evaluate the right carotid tree Partial obstruction of the right internal carotid artery immediately below the bifurcation was found (Fig 4b) The remaining extracranial aspect of the right common carotid the innominate and the right vertebral arteries appeared normal The left common carotid artery although it overlapped the cervical spine was smaller than the right indicating decreased blood flow secondary to the obstruction of the internal carotid artery identified in the left arteriogram (Fig 4a) Surgical correction of the left internal carotid artery was not attempted

Case 5 A 27 year old white male developed a sudden onset of diplopia followed immediately by weakness of the right face leg and arm which persisted for one week prior to admission at the West Haven Veterans Administration Hospital One year before this episode he had experienced vertigo nausea and ataxia which disappeared completely after several days

On admission the neurological examination revealed mild expressive aphasia and a right facial weak paralysis as well as a flaccid right upper extremity

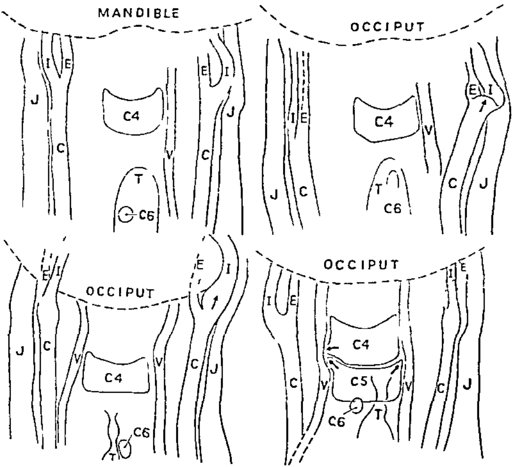


Fig 6 Composite tracings of arterial and venous phases of neck vessel filling during intravenous aortograms in 4 cases Vertebral body of C 4 subglottic region (T) and spinous process of C 6 serve as landmarks for Table 2 *Upper left* Carotid bifurcation displaying Y appearance *Upper right* Kinking of carotid bifurcation (arrow) thrombosis cannot be excluded in this projection *Lower left* Metastatic lymph nodes flatten and displace the internal carotid artery (arrow) *Lower right* Osteophyte indentation (arrows) of the vertebral arteries

with the neck in a slight degree of obliquity could be used to eliminate overlapping vessels particularly at the carotid bifurcation A single intravenous injection might then be used to not only delineate neck vessel narrowing in two places but outline the major intracerebral vessels as well

In most instances the frontal projection in our present series has appeared to be of greatest value When the carotid bifurcation has a Y configuration (Fig 6a) a satisfactory diagnosis of obstruction may be made Identification

of the internal carotid artery, however, as it arises from the bifurcation in the frontal plane, may be difficult In most of the cases examined, however the internal carotid artery arose lateral to the external carotid It then crossed the latter vessel, 2 to 3 cm above the bifurcation to occupy a more medial position In several cases the intersection and distal course of the two vessels were partially obscured by the occiput or mandible Kinking or overlapping of vessels at the carotid bifurcation (Fig 6b) can mask the presence of a thrombus In this situation, as well as in an indeterminate localization of the internal or external carotid artery, direct carotid arteriography is necessary for vessel assessment

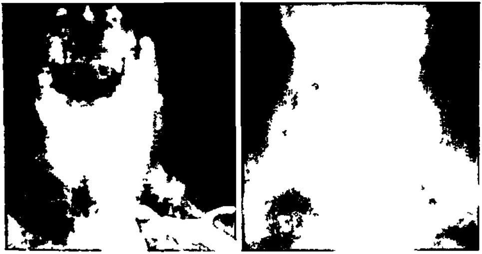
The frontal projection can be used to differentiate cervical aneurysms from carotid body tumors or enlarged lymph nodes Fig 6 c shows the lateral displacement and flattening of the left internal carotid artery due to adjacent metastatic node enlargement It is evident that a mass which produces only flattening of a carotid vessel could be confused with an aneurysm, and a single projection and a lateral arteriogram would be needed for further evaluation Additional filming would also be acquired to evaluate the significance of osteophyte compression of the vertebral arteries found in the a p projection (Fig 6d) Although in this case signs of vertebral artery insufficiency were present, retrograde aortic injection with the head in a sharp obliquity or lateral position would be necessary to estimate the amounts of postural occlusion that could be produced in the vertebral artery (SHEEHAN et coll 1960)

Initially it had been hoped that a difference in the degree of contrast filling of the internal jugular vein might serve to evaluate obstruction in a neck artery, as well as serve as a clue to the presence of intracranial arterial obstruction Normal variations of venous return, however, through the torcular Herophilus allows unequal distribution of the contrast medium to the jugular system As noted in Case 1 prominent jugular filling was present on the same side as the arterial obstruction in the neck

Table 1

Analysis of neck vessel fillin in 15 consecutive frontal plane intravenous aortograms

Origins outlined		Diagnostic opacification of neck vessels	
Innominate	14	Right common carotid	15
Left common carotid	11	Left common carotid	15
Left subclavian	8	Right vertebral	8
Right common carotid	12	Left vertebral	10
Right subclavian	7	Right jugular	11
Left internal carotid	13	Left jugular	11
Right internal carotid	11		
Left external carotid	7		
Right external carotid	6		
Left vertebral	4		
Right vertebral	4		



a b

Fig 7 Complications of intravenous aortographic method a) Reflux of contrast material in jugular vein during arm injection the patient did inadvertent valsalva maneuver b) Coughing episode during arterial phase of study Marked lateral excursion of common carotid artery is of physiologic interest only

In order to evaluate the amount and type of data obtained with the intravenous method the examinations of fifteen consecutive cases have been studied in detail from the standpoint of elucidation of vessel origins and outline of the course of major vessels in the neck Of importance in this evaluation is the fact that it was carried out in a single plane and the possibility of early thrombosis which could be seen only in a lateral projection is recognized An approximate 75 % incidence of satisfactory resolution of the origin of the internal carotid arteries could be seen, as noted in Table 1 Vertebral artery origin definition is much lower due usually to surrounding ribs overlying clavicle or soft tissues of the neck The innominate artery take off could usually be well demonstrated Reduced definition of the proximal segments of the left common carotid and left subclavian arteries was due to overlapping of these vessels in the frontal projection

One of the principal values of the intravenous method is the preliminary assessment of neck and mediastinal vessels it may provide prior to direct arterial injection In all of the cases studied the common carotid arteries were sufficiently contrast filled to estimate the degree of arteriosclerotic change present Approximately two thirds of the cervical vertebral arteries could be

Table 2

Average distance in centimeters of center of neck vessel from midline point measurements made in frontal plane intravenous aortograms in 15 consecutive cases corrected for magnification

	4th cervical vertebral body			Immediate subglottic region			Spinous process 6th cervical vertebral body		
	Average	Min	Max	Average	Min	Max	Average	Min	Max
Right vertebral	1 6	1 4	1 8	1 8	1 4	2 4	1 8	1.2	2 8
Left vertebral	1 6	1 5	1 8	1 7	1 1	1 8	1 8	1 4	2 0
Right common carotid	3 0	2 7	3 4	3 0	2 2	4 0	2 9	2.2	3 8
Left common carotid	3 0	2 5	3 6	2 8	2 1	3 2	2 8	2 2	3 8
Right internal jugular	3 9	3 8	4 4	3 9	3 2	4 5	3 9	3.2	4 6
Left internal jugular	4 2	3 0	4 7	3 7	2 8	4 5	3 8	2 8	4 5

Average distance of vertebrals from midline neck = 1 7 cm
Average distance of common carotids from midline neck = 2 9 cm
Average distance of internal jugulars from midline neck = 3 9 cm

satisfactorily seen In the majority of cases a disparity in the vertebral arteries could be detected and this knowledge could be used to govern selection of a vessel for direct injection

Table 2 has been prepared as a limited guide to the surface and topographical evaluation of the vertebral common carotid and jugular vessels in the adult neck, as measured in frontal plane angiograms The T' point denotes the vocal cords or immediate subglottic region and was chosen for its surface correlation with the thyroid cartilage Maximum and minimum distances of arteries from the midline point selected are directly proportional to the transverse measurement of the neck As would be expected the carotid and vertebral arteries are usually closer to the midline in thin patients and further lateral in individuals with heavy necks

Reference to Fig 6 indicates that chin posture produced little influence on the position of the carotid bifurcation as related to the thyroid cartilage The bifurcation was at least 1 5 cm or more above a transverse line drawn through the vocal cords in all the frontal plane angiograms examined This fact would suggest that common carotid puncture should always be carried out at or below the transverse level of the inferior aspect of the thyroid cartilage in order to avoid possible dislodgement of arteriosclerotic plaques in the carotid bifurcation

Acknowledgement

The authors wish to express their gratitude to Dr R. M Lowman and Dr J R Mitchell for their assistance in the preparation of this report.

SUMMARY

The intravenous aortographic method has been found useful as a screening procedure in the evaluation of the arteries of the neck and mediastinum. Its primary area of use would appear to be in older age groups, poor risk patients or in patients in whom multiple areas of atherosclerosis could be suspected. The method can also be employed as a preliminary assessment of the aortic arch and great vessels prior to direct arteriography. The information obtained may be used to select the direct arteriographic approach which will have the greatest diagnostic value and safety. The method gives a consistently high diagnostic definition of the innominate and carotid arteries and a satisfactory view of the origin of the internal carotid artery in the frontal plane in 75 % of the patients. The origins of the vertebral arteries were demonstrated in less than one third of patients examined.

ZUSAMMENFASSUNG

Die iv Aortographie hat sich als eine auf breiter Basis anwendbare Methode bei der Darstellung der Hals- und Mediastinalarterien bewahrt. Ihr primares Anwendungsgebiet scheint sich auf vorgeruckte Altersgruppen und Patienten mit ausgedehnter Arterioskleroses zu beschranken. Die Methode kann jedoch auch fur eine vorlaufige und grobe Untersuchung des Aortabogens und der grosseren Gefässe vor Durchfuhrung einer direkten Arteriographie angewendet werden. Nach dem Ergebnis der iv Aortographie soll diejenige (direkte) Arteriographie bestimmt und durchgefuhrt werden, die sowohl diagnostisch als auch was die Sicherheit betrifft den grossten Erfolg verspricht. Die Methode gewahrleistet eine gute diagnostische Darstellung der Aa. innominatae und carotis mit guter Darstellung des Abganges der A. carotis int. bei Frontalprojektion in 75 % der Patienten. Der Ursprung der Vertebralarterien konnte in weniger als ein Drittel der untersuchten Patienten dargestellt werden.

RÉSUMÉ

L'aortographie par voie intraveineuse s'est montrée utile pour un bilan d'ensemble des arteres du cou et du médiastin. Elle trouve ses indications de choix chez les sujets ages, les malades ont mauvais etat ou les malades chez qui on soupçonne de multiples localisations d'athérosclérose. Elle peut aussi etre utilisee pour un examen préliminaire de la crosse aortique et des gros vaisseaux avant artériographie directe. Les renseignements obtenus peuvent servir à choisir la voie d'abord de l'angiographie directe qui sera la plus utile au diagnostic et la plus sure. Cette methode donne constamment un diagnostic precis de l'état des troncs brachiocéphaliques artériels et des carotides et une précision satisfaisante pour l'origine de la carotide interne dans le plan frontal chez 75 % des malades. L'origine des arteres vertebrales n'a ete visible que chez moins du tiers des malades examinés.

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ZINNER G and GOTTLAB R Comparison of traumatic effect of different roentgen contrast media on blood vessels Fortschr Rontgenstr 91 (1959) 507

FROM THE SECTION OF NEURORADIOLOGY, DEPARTMENT OF RADIOLOGY, ST VINCENT S HOSPITAL OF THE CITY OF NEW YORK U S A

PERCUTANEOUS CAROTID CATHETERIZATION

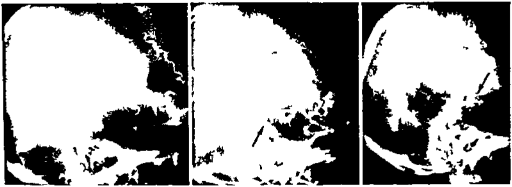
by

MANNIE M SCHECHTER

Many techniques of carotid catheterization have been attempted since MONIZ (1927) performed the first carotid angiogram and punctured the carotid artery both through an open exposure and percutaneously A new era in angiography seemed to be born with catheterization of vessels and advantages of using catheters soon became obvious the technique passing through various stages of development

As early as 1933 PARADE, and ROUSTHOI injected contrast medium into the coronary arteries in animals by introducing a catheter through the carotid artery ICHIKAWA (1938) reported a technique of arterial catheterization in man the catheter was introduced into the femoral artery (no mention was made as to whether this was performed percutaneously) and advanced into the aorta for contrast filling of the renal arteries FARINAS (1941) described a new technique for the arteriographic examination of the abdominal aorta and its branches introducing a trocar into the exposed femoral artery and then passing a ureteral catheter up into the aorta through the trocar RADNER (1947) whilst performing cardiac catheterizations inadvertently introduced a catheter into the vertebral artery via the radial artery and taking advantage of the chance passage developed this technique and later published a comprehensive monograph on the subject JONSSON (1949) performed thoracic

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a b c

Fig 2 Case of suspected meningioma a) Selective contrast filling of the external carotid artery shows no filling of tumor from this vessel b) and c) The catheter which was situated in the external carotid artery (a) has been withdrawn so that its tip lies in the common carotid artery Tumor filled from the internal carotid artery (This was a case of a secondary deposit from hypernephroma)

the needle The needle is withdrawn and the catheter is threaded over the guide and the two advanced together into the vessel The guide is then withdrawn leaving the catheter in position Using this technique the opening made in the artery by the needle is smaller than the catheter which is introduced LIVERUD (1955) published his work using the Seldinger technique for percutaneous carotid angiography in 1 000 cases without any fatal complications SUTTON (1956) has used this technique on a few occasions and has also used aortography via the carotid artery ELFTS (1960) published his experience using the Seldinger technique in angiography of the internal carotid artery WEINER AZZATO & MENDELSOHN (1958) described the technique of catheterization of a branch of the external carotid artery by exposing this vessel surgically and threading a catheter down to the common carotid artery

The present writer has since 1957 performed carotid catheterizations in over 1 000 instances using the percutaneous Seldinger technique

Advantages of the technique

The advantages of the percutaneous carotid puncture with anterograde and retrograde catheterization may be listed as follows

1 An extravascular or subintimal injection of contrast medium is eliminated since the catheter lies freely within the lumen of the vessel Intramural injections of contrast medium have occurred using the routine needle techniques a result of intimal damage by the sharp point of the needle (Fig 1 a and b) Numerous such complications have been reported resulting in transient hemiplegias cerebral infarctions and errors or false findings in angiography (MURPHY & SHILLITO (1959), FLEMING & PARK (1959) NEWTON & COUCH (1960) LIVERUD (1958) and KRISTIANSEN (1956)

SALTZMAN (1959) reported 101 extravascular injections of contrast medium *in a series of 1 020* cerebral angiographic studies No clinical complications were included

KRISTIANSEN (1956), interested in the problem of transitory hemiplegias and other accidents, stated that these are usually caused by *an inadvertent* production of a dissecting aneurysm of the carotid artery in *the neck This* results from the use of a sharp needle in the lumen of the vessel, producing damage to the intima KRISTIANSEN claimed that catheterization, using soft polyethylene tubing, has lowered the complications considerably and is the most important addition to the technique of angiography since the beginning of 1940

2 Selective contrast filling of the internal and external carotid artery is possible, eliminating the confusing superposition of branches one over the other The rate of flow in the internal artery is faster than in the external carotid artery, and this differential usually helps to distinguish the external carotid artery from the internal Not infrequently, however, external carotid vessels cannot be distinguished from internal carotid vessels The presence or absence of circulation supplied from the external carotid artery may be accurately determined (Fig 1c and 2)

Angiograms of the external and internal carotid arteries obtained at selective catheterization are represented in Fig 2 The patient was sent from another hospital with a diagnosis of a meningioma based on an angiogram in which it was thought that the tumor filled from the external carotid artery A selective external carotid angiogram (Fig 2a), performed at this hospital, showed no filling from the external carotid artery

3 Better definition is obtained since contrast material is delivered closer to the area of question with not much dilution

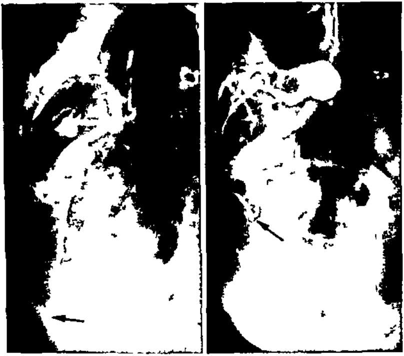
4 Smaller amount of the contrast medium may be used, that is 3 to 8 ml rather than 8 to 12 ml Adequate contrast has resulted from only 3 ml of Hypaque 50 %

5 Internal, external and common carotid angiograms may be obtained from a single puncture of the common carotid artery The catheter may be advanced into the internal and external carotid artery By withdrawing the catheter from either vessel its tip will be placed in the common carotid artery, and a common carotid angiogram will be obtained

6 The taking of multiple views such as determining the precise neck or site of an aneurysm is facilitated since there is freedom of movement of the head The submentovertical position is very easily achieved using this technique without fear of dislodging a needle (Fig 3)

7 Cross or contralateral compression is possible without fear of dislodging a needle

8 In difficult or recalcitrant patients once a catheter is in position the struggling movements will not result in dislodgement of the catheter, even if



a b

Fig 3 Submento-vertical views showing a middle cerebral aneurysm and an anterior communicating aneurysm This projection is facilitated by the use of a catheterization technique

it is withdrawn a centimeter or two during movements, because a few centimeters will still be present in the lumen of the vessel

9 Fewer hematomas result since the actual opening made in the vessel by the needle is smaller than the catheter which is squeezed through this The catheter has some give in its wall and contraction of the artery makes this a tighter fit

10 Patients can very easily be transported from one set of equipment to another by simply closing the tap at the end of the catheter before moving the patient

11 Injection of the internal carotid artery is possible without puncturing this vessel

12 Since the contrast medium is delivered closer to the carotid site lower concentrations of the medium may be used

13 The catheter may be introduced into the common carotid artery retrogradely and the origin of this vessel can be outlined By advancing the catheter still further in this direction on the right side the vertebral artery may also be outlined (Fig 4) (Berk 1960)



Fig 4 a) Catheter introduced retrogradely into the common carotid artery Filling of the anterior and middle cerebral arteries b) The catheter has now been advanced from down the right common carotid artery into the innominate artery The carotid and vertebral arteries with their branches are outlined

TINDALL & CUPP (1961) have outlined the origin of the carotid and vertebral arteries by introducing a needle into the right common carotid artery retrogradely and applying digital compression of the common carotid above the puncture site

The author has used this technique 10 times, with poor intracranial filling of the basilar artery and its branches The contrast filling at the origin of the vertebral artery and of its cervical course has been satisfactory

Disadvantages of the catheter technique

1 Thrombi or atheromatous plaques may be dislodged by the advancing catheter or guide This rare complication will be eliminated or reduced to a minimum by a careful technique To the experienced worker any slight obstruction to the passage of the guide or catheter during the carotid puncture will be recognized immediately and the guide may be withdrawn and the examination performed with the needle in position The author is not aware of any such complication in this series



a b c

Fig 5 a) Catheter in internal carotid artery with spasm of this vessel catheter highly placed areas of contraction b) After withdrawal a few centimeters of the catheter tip a repeat injection showed that spasm was no longer present c) Segmental constriction of the internal carotid artery stationary arterial waves

2 The technique via the carotid artery takes a few minutes longer than the routine carotid puncture but with experience can be performed as expeditiously

3 With a carotid artery puncture, pathologic conditions farther down in the neck might be missed since contrast is delivered at a higher level than the puncture site Should pathologic conditions be suspected here the catheter may be withdrawn a little or introduced retrogradely from the start

4 Spasm sometimes occurs near the tip of the catheter and may give false positive findings This may sometimes be corrected by withdrawing the catheter a little (Fig 5 a and b) The brachial artery seems to be the vessel most commonly affected by spasm

5 Arteriosclerotic tortuous vessels might prohibit or make a carotid catheterization technically impossible or difficult

The complications of the carotid puncture will be separated from those resulting from catheterization via a more remote portal of entry such as the radial brachial subclavian and femoral arteries All of the 820 carotid punctures were made with an 18 gauge thin wall needle introducing a PE 160 polyethy

lene tubing and 8 ml of either Hypaque 50 % or Renografin 60 % Most of the injections were made by hand Of the local complications, hematomas appeared to be rarer than when using the conventional needle techniques Two large hematomas necessitating tracheotomies were encountered One hematoma resulted from inadequate compression over the puncture site after the examination and one from damage to the arterial wall by the attempted removal of a bent guide which caught on the edge of the vessel opening The guide was bent because of poor technique The incidence of hematoma is lower using the catheter technique, since the opening in the artery is not stretched by a rigid needle which has all movements of the head and neck transmitted to it Hematomas are commoner in the hypertensive and arteriosclerotic patients and the incidence is usually associated with the skill and care of the operator

When spasm occurs, it is usually opposite the tip of the catheter (Fig 5, a and b), sometimes at the puncture site in the arterial wall Radiologically recognizable spasm occurred in 5 % of cases in this series This includes the very minor changes in the lumen of the vessel referred to by THEANDER in 1960 (Fig 5c) These are small concentric constrictions of the lumen of the vessel, giving the appearance of a string of pearls which have the perforated ends flattened That these are not organic is proven by the varying pattern, particularly when the catheter has been withdrawn a little and a second injection made (Fig 5, a and b) Also included in this 5 % is the marked narrowing of the vessel which could compromise the circulation This marked narrowing occurred in 0 5 % of the cases There was no evidence of a greater incidence of vascular disease or intracranial disease in patients displaying this phenomenon than in those not showing it When spasm occurred it was most obvious in those cases in which the catheter was introduced too far up in the internal carotid artery, that is, near the carotid siphon, or where a difficult or protracted introduction had occurred Marked spasm has also occurred in a few cases where the contrast medium had passed into the tissues around the vessel wall Spasm was commoner with the large size catheters In five cases of transitory hemiplegias marked spasm of the carotid artery was seen Spasm may sometimes simulate organic disease and when marked may cause retardation of the circulation The streaming effect, under these circumstances may result in a picture not unlike occlusive disease (SCHECHTER & ELKIN 1963)

WICKBOM & BARTLEY (1957) reported 108 angiograms using catheterization and in two of the cases examined by catheterization of the carotid artery complications arose due to spasm ELFIN (1960) had 2 cases of spasm in the 124 studies he performed, and after withdrawing the catheter a little the examination was completed without any signs of spasm

No arteriovenous fistulae appeared in this series nor were there any cases of thrombosis of the carotid artery In two cases the tip of the metal guide broke off and in one case lodged in a branch of the external carotid artery In the

second case the tip remained in the soft tissues of the neck This was a result of poor technique The author is not aware of any perforation of the carotid artery with false passage of the guide or catheter using this technique, nor were any dissecting aneurysms encountered in this series The complications of carotid angiography in general have not been discussed

SUMMARY

The techniques of carotid catheterizations are described Percutaneous carotid catheterizations have been performed by the author in over 1 000 instances the advantages and disadvantages of the technique are discussed The complications encountered by the author are also discussed

ZUSAMMENFASSUNG

Die Methoden der Katheterisierung der Art carotis werden beschrieben Es wurden vom Autor mehr als 1 000 perkutane Katheterisierungen durchgefuhrt die Vor und Nachteile der Technik sowie aufgetretene Komplikationen werden besprochen

RÉSUMÉ

L auteur décrit les percutanés techniques de cathétérisme de la carotide Il a fait plus que 1 000 cathétérismes percutanés de la carotide il examine les avantages et les inconvénients de cette technique Il étudie aussi les complications qu il a rencontrées

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FROM THE DEPARTMENT OF RADIOLOGY (DIRECTOR PROF M ELKIN) ALBERT EINSTEIN COLLEGE OF MEDICINE YESHIVA UNIVERSITY NEW YORK U S A

LAYERING EFFECT IN CEREBRAL ANGIOGRAPHY

by

MANNIE M SCHECHTER and MILTON ELKIN

The diagnostic accuracy of arteriographic studies is improved by a better understanding of the blood flow in the vessels as well as from modifications of this flow by the contrast media used The blood flow in a vessel with almost parallel walls is laminar or streamlike whereas the flow distal to a constriction is turbulent Hence, the mixing of a contrast material with the blood will vary with the character of the flow These factors have been studied by many authors (1 2 3, 4 11)

The nature of the contrast medium is also of great importance The iodine containing media that are now being used in arteriography are of higher specific gravity than blood and blood mixed with such a contrast medium is heavier than pure blood Thus a Hypaque 50 % solution has a specific gravity of 1 32 and Renografin 60 % has a specific gravity of 1 33 at 20° C A comparison of specific gravities is given below

Water	1 000	Hypaque	1 32 at 20 C
Blood	1 057 + 0 005	Renografin	1 33 at 20 C
Serum	1 025 + 0 003		

Hence in the absence of thorough mixing the various concentrations of the contrast media in blood will form fluid levels that depend upon their relative gravities the heavier fluid mixture layering below the mixtures of lower specific gravity (Fig 1) The importance of this layering phenomenon in

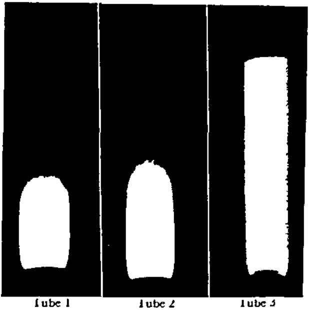


Fig 1 Roentgenograms of three tubes containing citrated blood 5 ml of Hypaque 50% were carefully poured down the side of each tube Tube 2 was inverted once tube 3 was agitated for half a minute (this view was taken five hours after introduction of the contrast medium) Fluid levels in tubes 1 and 2 in tube 3 the contrast filling is homogenous and persisted

roentgen examinations of the urinary system has been demonstrated by several investigators (5, 6 7, 13)

Since the contrast medium introduced intra arterially is usually carried as a bolus with normal blood flow, there is some mixing, and usually the layering effect is not obvious in the vessels The bolus is rapidly carried through the vessels being investigated However, when the circulation is slowed down, as with increased cerebral pressure and stenotic disease in the vessels (Fig 2), or spasm associated with subarachnoid bleeding the layering effect may be apparent (Fig 3) The retardation of the circulation may be caused by the procedure itself as with subintimal injections during cerebral angiographs with needle puncture of the vessel (Fig 4) Spasm may slow down the circulation (Fig 3), and since this is now an accepted phenomenon in the region of aneurysms the layering effect will be accentuated in these aneurysms

Failure to understand this phenomenon may lead to misinterpretations of the calibre of a major vessel (Figs 4 and 5) In as much as the mixture of contrast medium and blood sinks to the most dependent portion of the vessel, the diameter of the opaque column will in such cases be less than the actual diameter of the vessel Hence a diagnosis of marked organic narrowing or spasm of a vessel may be mistakenly made when in actual fact the vessel is normal in calibre (Fig 4)



a b

Fig 2 Carotid occlusion at the level of the carotid siphon a) *Normal calibre of the internal carotid* artery b) The layering effect is apparent the contrast medium hugs the posterior wall of the carotid artery since the angiogram was performed in the supine position



a b

Fig 3 Carotid catheterization two separate injections a) *The fluid level in the carotid siphon* is due to slow circulation from spasm of the internal carotid artery b) Separate injection shows no abnormality in the region of the carotid siphon

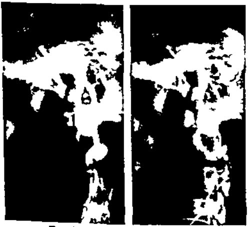


Fig 4a Fig 4b

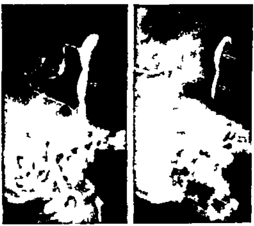


Fig 5a Fig 5b

Fig 4 Vertebral angiography with some extravascular passage of contrast medium around the vertebral artery resulting in slowed circulation and enhancing the layering effect b) Same injection as in (a) one second later The basilar artery is represented by a markedly reduced stream of contrast medium which in the supine position is only a fraction of the lumen of this vessel since it hugs its posterior wall

Fig 5 Fusiform aneurysm of basilar artery a) Incomplete filling of the basilar artery b) Same injection one second later Fluid levels in the basilar artery



Fig 6 Two glass aneurysms Saline was passed through both limbs of the anterior communicating system to represent the blood flow and contrast medium was then introduced into the one limb There is a fluid level in the aneurysms The glass aneurysms were also used in our experimental system using the image intensifier and cinefluorography a) Anterior communicating aneurysm b) Saccular aneurysm arising from a single branch

a b

The layering effect in the basilar artery may result in an angiographic appearance which has been mistaken for occlusive disease in this vessel (Fig 4) The anatomy of this region lends itself uniquely to this phenomenon When contrast medium is introduced into one vertebral artery, it is carried up in a bolus to the basilar artery, where it diffuses with the blood passing up from the opposite vertebral artery A jet stream is often identifiable at the point of union of the two vertebral arteries This jet effect is usually limited to the point of junction and is not seen further along the vessel

When contrast medium is introduced directly into a vertebral artery, this effect is usually absent, since the density of the column of contrast is such that even some dilution with blood from the opposite vertebral artery is not sufficient to cause a visible jet stream When, however, the vertebral artery is contrast filled via the subclavian or the carotid artery, the contrast medium in the vertebral artery is already diluted, and when this contrast stream eventually meets the blood from the opposite side the jet effect is more evident The appreciation of this phenomenon will obviate a mistaken diagnosis of vascular occlusive disease in the basilar artery

The layering effect may be of real importance in the demonstration of cerebral aneurysms, depending on the position of the neck of the aneurysm as well as on the size of the aneurysm

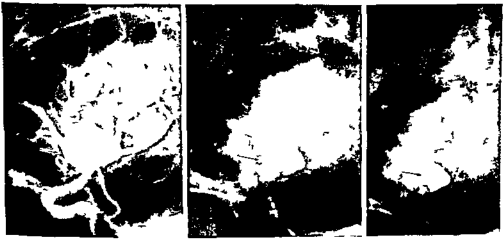
If the opening of the aneurysm arises from the most dependent wall of the vessel, then the aneurysm will fill rapidly with contrast medium and will tend to empty itself slowly of the blood/contrast mixture In large aneurysms so located, especially with a relatively narrow neck, the contrast material will remain in the aneurysm long after the regular lumen of the artery is emptied of it These factors are accentuated by the spasm which slows the circulation



a b c

Fig 7 Aneurysm of the middle cerebral artery Representative films of a series taken at 1 5 sec intervals a) Incomplete filling of the aneurysm b) Aneurysm almost completely filled c) Complete filling which has taken place from behind and forwards

considerably in the region of the aneurysm Such an aneurysm will be emptied of contrast medium first in the region close to its neck and finally from its fundus as the heavier blood/contrast mixture is gradually replaced by blood alone Hence, an exposure with a horizontal beam during the period of gradual emptying will show an isolated collection of contrast material generally round at the bottom and level or concave outwards at the top From such an appearance it may be derived that the neck of the aneurysm is close to the level portion rather than the rounded portion (Figs 6 7 8)



a b c

Fig 8 Anterior communicating an u m series of films taken at 1 5 sec intervals a) Complete filling of the aneurysm b) Aneurysm i emptying from in front c) Incomplete emtying flu d level

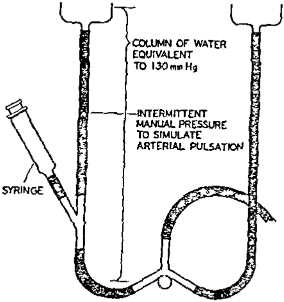


Fig 9 Schematic representation of the experimental set up The contrast medium (Hypaque 50) is introduced through a syringe and water in the reservoirs is controlled to simulate blood flow and arterial pulsation in vessels

On the other hand, if the aneurysm arises from the superior aspect of the vessel, then there may be incomplete filling or even lack of filling of the aneurysm by the blood/contrast mixture Also once filled, such an aneurysm will empty itself rapidly of the contrast medium (Fig 11)

When two major vessels appear to be intimately associated with an aneurysm a careful study of the serial films may show a small area of the aneurysm clearing of contrast medium before the rest of the lesion This is the point of attachment of the aneurysm and may indicate its parent vessel

Hence, the position of the head of the patient may be of great importance *in the radiologic demonstration of an aneurysm, as well as in determining the* site of the aneurysmal opening

This appearance was first reported by MARGUTH & SCHIEFER (1957) and by RAUSCH & SCHIEFER (1956) HUBER (1961) in a recent publication also describes this effect and shows a serial angiography of an aneurysm with a fluid level KLAUSBERGER (1958/59) states that because of this phenomenon certain aneurysms might not be seen at all He advocates the use of cineroentgenography with sixty frames a second for 12 to 15 seconds, and during the full length of the exposure the patient rotates the head through 90° from side to side In this way small aneurysms may be outlined which may otherwise be missed Apart from the advantage of these multiple views on a pure projectional basis, it is possible that in one particular position there may be better filling of the aneurysm Subarachnoid bleeding with a negative finding at angio-

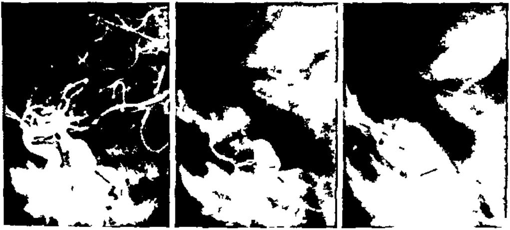


Fig 10 Angiography performed in supine position Emptying of a posterior communicating aneurysm with a long neck a) Aneurysm completely filled b) 1 5 sec later fundus filled fluid level c) Some contrast medium is still present in the fundus of the aneurysm

graphy may perhaps have the aneurysm demonstrated by a repeat study with the head in an altered position

MARGUTH & SCHIEFER claim that perhaps the slower circulation that occurs at the farthest point from the opening of an aneurysm (i e the fundus) may be responsible for the thrombus which sometimes occurs in this region

The importance of the layering effect attracted our attention in the inter

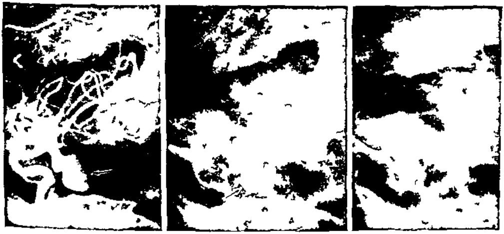


Fig 11 Angiography prone position sa ase as in fig 10 In ompl te filling of the fundus of the aneurysm (1 5 s c later the contrast m i m had left the aneurysm) Co npare emptying of aneurysm n pr ne and supine pos tions At post n t m a long saccular aneurysm of the posterio communicating artery was seen it corresponded w th t e ang ogr ph c appea ances

pretation of angiographic findings of several of our patients We have illustrated these basic principles by the use of glass models of aneurysms using cine fluorography (Fig 6), in our experimental system we have used water to represent blood and Hypque 50 % as the contrast medium (Fig 9) In addition we have made colored movies of our experimental model, the Hypaque solution being colored with methylene blue

Using both of these techniques, the layering effect has been most adequately demonstrated with our angiograms, and the correlation of these appearances has been most striking Cases exhibiting the layering effect during cerebral angiographies as well as roentgenograms of cases studied both in the supine and prone positions are illustrated in Figs 10 and 11

SUMMARY

The basic principles of the layering effect are discussed and illustrated in roentgenograms obtained in both prone and supine positions Failure to recognise the phenomenon may result in false interpretations of films whilst applying the principles may give added information in terms of the precise origin of an aneurysm from the parent vessel

ZUSAMMENFASSUNG

Das Prinzip des Schichtungseffektes wird an Hand von Rontgenbildern besprochen die sowohl in Bauch als auch in Ruckenlage angefertigt worden Nichtbeachtung des Phanomens kann diagnostische Fehler bedingen wahrend dessen Kenntnis besondere Informationen im Falle der Darstellung eines Aneurysmas und dessen Ursprungs gibt

RÉSUMÉ

Les auteurs étudient le mecanisme de l effet de sédimentation du moyen de contraste et en donnent des exemples radiographiques Ils ont radiographié leurs malades en procubitus et en décubitus La meconnaissance de ce phénomene peut entrainer une erreur d interprétation des films alors qu en utilisant les principes de ce mécanisme on peut obtenir des renseignements supplementaires sur l origine précise d un anévrisme a partir du vaisseau qui le porte

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AUS DER NEUROCHIRURGISCHEN ABTEILUNG (DOZENT DR W DRIESEN) DER CHIRURGISCHEN UNIVERSITATS KLINIK (PROF DR W DICK) UND DEM MEDIZINISCHEN STRAHLENINSTITUT DER UNIVERSITAT TUBINGEN (PROF DR R BAUER), DEUTSCHLAND

BEZIEUNGEN ZWISCHEN DER LAGEANORDNUNG DER ZENTRALEN HIRNVENEN UND DER SCHADELKONFIGURATION

von

H SCHMIDT und U ROSSI

Neuzeitliche Untersuchungen haben sichere Korrelationen zwischen der Form des Schadels und der Lage der medianen und paramedianen subcorticalen Strukturen ergeben Auch ist festgestellt worden dass sich der Hirnstamm nach der Schadelbasis orientiert (DELMAS & PERTUISET) Es ist anzunehmen, dass auch die Lageanordnung der Hirngefasse der Form des Schadels entspricht So fallt bei cerebralen Phlebogrammen auf dass bei Brachycephalie z B die Gefasse anders liegen als bei Dolichocephalie Die genaue Aufzeichnung solcher Feststellungen konnte neue Ausblicke fur die hirnangiographische Diagnostik bringen wenn objektiv verwertbare Beziehungen zwischen den Varianten in der Lageanordnung der zentralen Hirnvenen und der individuellen Schadelkonfiguration festzustellen waren

Die gewohnlich angewandten Methoden zur Deutung von cerebralen Phlebogrammen beziehen die Lage des Angulus venosus mit Hilfe spezieller Topogramme auf cranielle Punkte, Linien oder Winkel Die grosse Variabilitat in der Lagebeziehung zwischen anatomisch definierten einzelnen Punkten

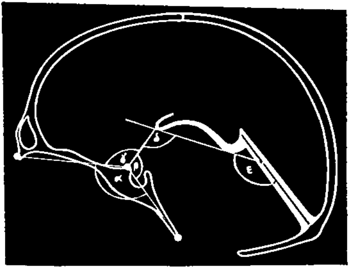


Abb 1 Situationsskizze mit eingezeichneten Winkeln in Abhangigkeit zum Tuberculum sellae

des Gehirns einerseits und des Schadels andererseits hat jedoch den Wert bisheriger Untersuchungen solcher Zusammenhange fur die Praxis entscheidend beeintrachtigt Starker als bei der Lagebestimmung einzelner Punkte des Gehirns, vor allem also des gut im Phlebogramm zu bestimmenden Foramen Monroi muss sich die Schadelkonfiguration auf die Lage zweier Punkte definiert durch eine Strecke im Gehirn auswirken

Es wurde deswegen eine eigene graphische Methode angewandt, mit der im seitlichen Phlebogramm das tiefe venose System mit der Schadelbasis und der Calotte in zwei Serien von je 100 normalen Phlebogrammen korreliert wurde Die Venenlinie ist durch die Tangente an den Scheitelpunkten der beiden caudal konvexen Bogen die vom Angulus venosus und von der Ampulla Galeni gebildet werden, dargestellt Zieht man eine Verbindungslinie vom Tuberculum sellae — als relativem Punctum fixum der Schadelentwicklung und damit auch samtlicher Knochenpunkte des ausgebildeten Schadels — zum Scheitelpunkt des vorderen der beiden Venenbogen entsprechend der Lage des Foramen Monroi dann wird ein Winkel δ gebildet dessen Grosse unter anderem auch die Neigung der Venenlinie wiedergibt (Abb 1)

Setzt man diesen Winkel δ in Beziehung zum basalen Winkel des Schadels (Angulus sphenoidalis von Welker), dann ubersteigt nach Ausrechnung einer Haufigkeitsverteilung der Korrelationsfaktor mit 0 35 nur unwesentlich die Grenze der Signifikanz Wesentlich deutlicher wird die Korrelation wenn man den frontalen und den occipitalen Schenkel des Basiswinkels jeweils getrennt betrachtet und die Winkel die sie mit der Linie Tuberculum sellae — Fo-

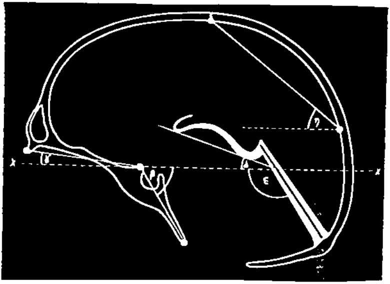


Abb. 2. Situationsskizze mit eingezeichneten Winkeln in Abhängigkeit zur Filmrandparallelen (gestrichelte Linien)

ramen Monroi bilden, β und γ, mit dem vorerwähnten Winkel der Basislinie in Bezug setzt (Abb. 1). Die Korrelationsfaktoren betragen 0,67 für den occipitalen und 0,69 für den frontalen Schenkel des Basiswinkels. Wenn also der frontale Schenkel ansteigt, nähert sich die Basislinie mehr der Vertikalen, wenn der occipitale Schenkel ansteigt, näher der Horizontalen. Durch diese Spreizungen seiner Schenkel vergrössert sich jeweils der Basiswinkel, doch ist die Auswirkung auf die Stellung der Basislinie, je nach dem, ob die Vergrösserung des Basiswinkels mehr durch die Hebung des occipitalen oder des frontalen bedingt ist, jeweils eine gegensätzliche. Hierdurch erklärt sich die mangelnde Korrelation zwischen dem Venenlinienwinkel δ und dem Basalwinkel α. Das geht aus den erzeugten Korrelationsfaktoren bei der 1. Untersuchungsserie von 100 normalen Phlebogrammen hervor:

α : δ r = 0,35 $\qquad$ α : ε r = — 0,43

β : δ r = 0,69 $\qquad$ β : ε r = 0,51

γ : δ r = 0,67 $\qquad$ γ : ε r = 0,51

δ : ε r = 0,80

Die Grösse des Venenlinienwinkels ist auch von der Lage des Foramen Monroi zum Tuberculum Sellae abhängig und damit kein absolutes Mass für die Neigung der Venenlinie.

Um hiervon unabhängig zu werden und um allein die Neigung der Venenlinie zu erfassen, wurde nach dem Nachweis der Korrelation zwischen β, γ und δ geprüft, ob die Neigung der Venenlinie mehr mit der Konfiguration

der Schadelbasis oder mehr mit der Calottenform des Schadels zusammen hangt Als von der Schadelform wie von der Gefasslage unabhangige Vergleichslinie wurde eine Parallele zum Filmrand gezogen und auf diese die Schragen des occipitalen und frontalen Schenkel des Basiswinkels die Schrage der Basislinie weiter des Sinus rectus und schliesslich auch die Schräge der Strecke zwischen dem Endolambda und dem Endobregma als Mass der Calottenschrage bezogen (Abb 2)

Man kann die Parallele zum Filmrand bedenkenlos als Hilfslinie nehmen solange man nicht den Beweis der Korrelation führen muss — das ist schon geschehen —, da es nur auf das Verhaltnis der einzelnen Schragen im individuellen Fall zueinander ankommt nicht auf die absoluten Werte Die Korrelation wird naturlich absolut wesentlich hoher als zuvor, weil sie allein durch die unterschiedliche Kopfhaltung zum Filmrand in der Gesamtheit der Falle aller gemessenen Schragen jeweils gleichsinnig verandert ist Schon hierdurch tritt die Korrelation ein Die Korrelationsfaktoren bei der 2 Untersuchungsserie von 100 normalen Phlebogrammen sind der untenstehender Aufstellung zu entnehmen

δ γ r = 0 82	δ β r = — 0 90
ε γ r = 0 77	ε β r = — 0 85
η γ r = 0,82	ε η r = — 0 92

δ η r = 0 85

Folgende Schlussfolgerungen darf man unseren Untersuchungen entnehmen

Positive Korrelationen bestehen zwischen der Schadelkonfiguration und der Lageanordnung der zentralen Hirnvenen

Die Korrelationen sind für die tiefen Venen starker als für den Sinus rectus, trotz der Anheftung des Sinus rectus an den Schadel

Sowohl die Venenlinie wie auch der Sinus rectus tendieren in ihrer Schraglage stärker zum occipitalen Schenkel des Basiswinkels als zum frontalen

Es besteht keine wesentliche Differenz in der Korrelation der Venenschragen zu den Schragen der Schadelbasis einerseits und der Calotte andererseits

Die Untersuchungsergebnisse mogen die Grundlage bilden für eine masstechnische Analyse von Lageveranderungen der zentralen Hirnvenen in pathologischen Fallen wobei es jetzt moglich ist die manchmal sehr ausgepragten individuellen Varianten der Gefasslage zu berucksichtigen

ZUSAMMENFASSUNG

Die Lage der zentralen Venen entspricht in unterschiedlichen Ausmass der individuellen Schadelform Entsprechende Korrelationsrechnungen dienen als Grundlage für die Diagnose pathologischer Lageabweichungen der Hirnvenen unter Berucksichtigung dieser Formvarianten

SUMMARY

The position of the central cerebral veins corresponds in a varying degree to the individual shape of the skull Mathematical corrective formulae serve as a basis for the diagnosis of any pathologic displacement of the cerebral veins taking into the account varying types of skulls

RÉSUMÉ

La situation des veines profondes du cerveau dépend dans une mesure variable de la forme du crane Pour tenir compte de ces variations de forme le diagnostic des déplacements pathologiques de ces veines est base sur le calcul des corrélations entre leur situation et la forme du crane

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FROM ROENTGENDIAGNOSTIC DEPARTMENT II (DIRECTOR DOCENT I WICKBOM), AND DEPARTMENT OF PATHOLOGY II (DIRECTOR PROF S RANSTROM), SAHLGRENSKA SJUKHUSET, GOTHENBURG SWEDEN

VASCULAR SUPPLY OF INTRACRANIAL DURA FROM INTERNAL CAROTID ARTERY WITH SPECIAL REFERENCE TO ITS ANGIOGRAPHIC SIGNIFICANCE

by

LARS BERTIL SCHNURER and STURE STATTIN

The intracranial dura mater is supplied mainly by the middle meningeal branch of the external carotid artery Small meningeal branches of the ascending pharyngeal occipital and superficial temporal arteries as well as other branches of the external carotid artery augment the supply The dura at the base of the skull is also supplied by small vessels from the cavernous portion of the internal carotid artery Apart from the inferior hypophyseal artery branches of the cavernous portion of the internal carotid artery are described somewhat briefly in the anatomical literature, and illustrations demonstrating the origin and course of these branches are lacking These vessels were described in more detail in a recent paper by DE LA TORRE & NETSKY mostly concerned with their embryological aspects The vessels have received practically no attention in the angiographic literature although they are mentioned by HUBER in a paper on the primitive trigeminal artery

WICKBOM & STATTIN in a paper on meningiomas at the Symposium Neuroradiologicum in Bruxelles in 1957 described a vessel which arising from the proximal portion of the carotid siphon partly supplied a tentorial meningioma STATTIN in another paper described this vessel in 8 cases of tentorial meningioma

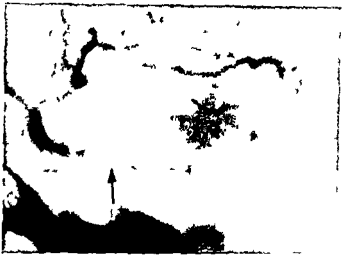


Fig 1 Meningeal branch of the cavernous portion of the siphon supplying a tentorial meningioma (arrow)

verified at operation and in 7 additional cases in which neither operation nor autopsy was performed The vessel supplied a vascular malformation in at least two of the latter 7 cases An example of this meningeal vessel is shown in Fig 1

The same vessel has apparently been described by BERNASCONI & CASSINARI in 5 cases of tentorial meningioma FRUGONI et coll, in reviewing their angiographies, found the same peculiar vessel in 8 cases of tentorial meningioma in 2 cases of meningioma of the falx, and in one case of parasagittal meningioma BERNASCONI & CASSINARI as well as FRUGONI et coll were uncertain as to the origin of the vessel because the contrast medium had been injected into the common carotid artery

We have examined a number of specimens of the base of the skull obtained at autopsy in order to determine the true nature of this tentorial vessel These specimens have included the middle cranial fossa and adjacent parts of the anterior and posterior fossa including the foramen magnum Special care has been taken not to damage the tentorium and basal dura attached to the specimen Contrast medium, a dye, or a plastic solution has been injected into the internal carotid artery after the siphon has been ligated distal to the origin of the ophthalmic artery The cavernous sinus has then been opened and the branches arising from the carotid artery have been dissected under a dissection microscope The origin and course of the vessels and relations to surrounding structures have been studied and drawings and photographs made during the dissection The vessels were injected and very small twigs successfully dissected in about 15 of the specimens Our primary aim was to demonstrate the internal

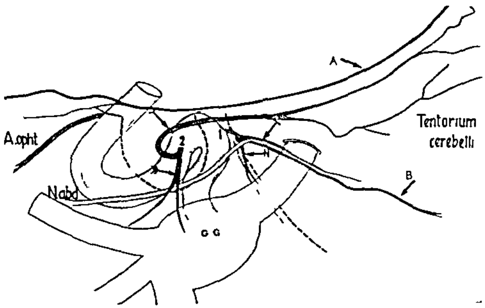


Fig 2 Schematic drawing illustrating a lateral view of the left carotid siphon clivus and sella are drawn with dotted lines A — free margin of tentorium B — attachment of tentorium to the petrous portion of the temporal bone G G — gasserian ganglion 1 — dorsal main stem with the basal tentorial branch (<—) and clival branches (↔) 2 — lateral main stem with the marginal tentorial branch (→) and branches to the gasserian ganglion and adjacent structures including the dura of the middle fossa (→)

carotid supply of the tentorium and basal dura and our results concerning this supply will be reported in some detail Figs 2 and 3 are schematic drawings to illustrate our findings

The anatomy varies somewhat from case to case but in the main the number and course of the major branches are fairly constant In most cases two main branches arise from the cavernous portion of the siphon and these we have called the dorsal main stem and the lateral main stem The dorsal branch arises from the proximal portion of the siphon at the upper posterior aspect of the convexity The lateral main stem arises a little more anteriorly, from the so called horizontal portion of the siphon generally from its infero lateral aspect Both main stems generally give off branches to the tentorium but in some cases branches are produced from one stem only

The tentorial branch of the dorsal main stem passes backwards, upwards and slightly laterally to enter the tentorium anterior to the apex of the petrous bone it then continues backwards in the tentorium near its attachment to the petrous bone We have called this vessel the basal tentorial' branch and it ramifies in the adjacent basal portion of the tentorium

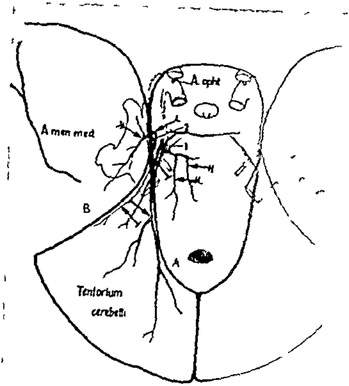


Fig 3 Schematic drawing illustrating the base of the skull seen from above A — free margin of tentorium B — attachment of tentorium to the petrous portion of the temporal bone 1 — dorsal main stem with the basal tentorial branch (←—I) and clival branches (←—II) 2 — lateral main stem with the marginal tentorial branch (←—) and branches to the gasserian ganglion and adjacent structures including the dura of the middle fossa (⟼)

The tentorial branch of the lateral main stem in most cases runs directly upwards to enter the tentorium slightly behind the attachment of its free margin to the anterior clinoid process It continues backwards near the free margin of the tentorium following the fourth nerve to ramify in the adjacent marginal portion of the tentorium We have called this vessel the marginal tentorial branch

Variations have been noted, and in some cases the basal tentorial branch arises separately from the upper dorsal convexity, generally lateral and posterior to the dorsal main stem It usually also continues backwards in these cases near the attachment of the tentorium to the petrous bone If the tentorial branch of the lateral main stem is missing the tentorial branch of the dorsal main stem generally runs near the free margin of the tentorium It has been possible to follow the tentorial vessels a varying distance backwards depending upon the size of the vessels and upon the success of the contrast injection and dissection The marginal vessel has sometimes been followed up



Fig 4 Dorsal view of the clivus with both carotid siphons The dorsal main stem (—→) with anastomosing clival branches and inferior hypophyseal artery which on the left side is visible but on the right hidden behind the dorsum sellae Small separate hypophyseal artery on the right side (I—→) Basal tentorial branch (II—→) arising separately from the upper dorsal convexity of the siphon

to the summit of the tentorium and in one case the vessel could be seen to pass over to the basal portion of the falx

Some of the other branches arising from the cavernous portion are of interest in connection with the dural vascular supply Vessels arising from the dorsal main stem or from the inferior hypophyseal artery pass medially over the lateral margin of the clivus and anastomosing with corresponding vessels of the other carotid artery, constitute a network of vessels freely supplying the dura of the dorsum sellae and clivus Vessels arising separately from the siphon in some cases augment the supply of the clival dura Clival branches have occasionally been followed backwards to the foramen magnum and branches have also been seen to enter the internal auditory meatus

The lateral main stem after having given off the marginal tentorial branch, passes downwards and laterally over the lateral aspect of the sixth nerve and then again downwards, under, through, or lateral to the fifth nerve The vessel gives off several branches to surrounding structures — the gasserian ganglion the fourth fifth and sixth nerves and to the walls of the cavernous sinus It then continues downwards to the dura of the middle fossa in which it ramifies freely anastomosing with branches of the middle meningeal artery Other branches of the lateral main stem pass forwards and laterally to the ala parva and the dura of the posterior portion of the anterior cranial fossa Small twigs also pass through the superior orbital fissure or directly through the greater wing of the sphenoid to the orbit where they anastomose with branches of the ophthalmic artery



Fig 5 Freely anastomosing vessels on the clivus Basal tentorial branch (arrow pointing downwards) of left dorsal main stem runs backwards along the petrous bone Inferior hypophyseal artery (arrow pointing upwards) of the dorsal main stem





Fig 6 Lateral view of left siphon The marginal tentorial branch of the lateral main stem closely follows the sixth nerve (—•) backwards to enter the tentorium at the apex of the petrous bone (⊢—•) and continue near its free margin The largest portion of the lateral main stem goes beneath the gasserian ganglion (here divided to demonstrate the vessels) and ramifies in the middle fossa

Fig 7 Almost aneurysmal widening of proximal portion of lateral main stem. Marginal tentorial branch (—•) runs upwards to enter the free margin of the tentorium Basal tentorial branch (⊢—•) arising separately from the upper dorsal convexity of the siphon runs backwards under the sixth nerve

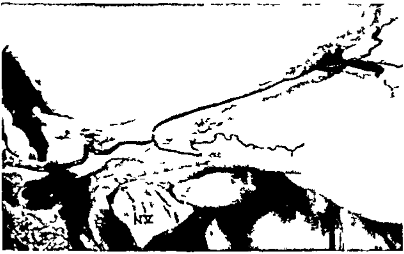


Fig 8 Marginal tentorial branch ramifying in tentorium NV — nervus trigeminus

Photographs taken during the dissection are shown in Figs 4 to 8

The marginal tentorial branch in lateral roentgenograms of the specimens also seems to arise from the posterior aspect of the convexity because its proximal portion is hidden behind the dense siphon This is evident in Fig 9

Summing up it may be said that this investigation indicates that the tentorium is to a large extent supplied by vessels arising directly from the cavernous portion of the carotid artery It is thus most likely that the vessels supplying tentorial meningiomas and vascular malformations, as described by WICKBOM & STATTIN inter alios are hypertrophied vessels arising from the cavernous part of the siphon

Small vessels in the neighbourhood of the siphon are visible in most angiographies in lateral views obtained during the arterial phase The origin and nature of these vessels are often difficult to determine and some of them may appear to arise from the siphon as they pass backwards and cross it e g (a) branches of the first portion of the middle cerebral artery supplying the most anterior part of the temporal lobe (b) the posterior branch of an anomalous middle meningeal artery arising from the ophthalmic artery

Small branches of the posterior communicating and posterior cerebral artery may in some cases also appear to arise from the siphon and like the vessels mentioned above are to be differentiated from true branches of the siphon The tentorial branches also have a characteristic wavy appearance similar to other dural vessels and this may be found a help in differentiating them from cerebral vessels The primitive trigeminal artery may generally be easily differentiated from other branches It joins the basilar artery and usually arises from the siphon rather low down If however the anastomosis is narrow

Fig 9 Lateral roentgenogram of a specimen The marginal tentorial branch also seems to arise from the convexity of the siphon





a b

Fig 10 Subtraction angiography in living subjects. a) A vessel arising from the left carotid siphon can be followed about 25 mm backwards (Metal clips are from surgical ligation of right sided middle cerebral arterial aneurysm) b) Small vessel from the siphon in a case of epilepsy

and incompletely contrast filled and if the proximal part of the siphon has a straight course the differentiation may be difficult

We have found that the determination of the true nature of all these vessels is facilitated by stereoscopy and the subtraction technique described by Ziedses des Plantes has also been of much help Using such methods we have in a number of normal angiograms found a vessel which we believe arose from the siphon This vessel has been followed backwards for a distance varying from about 5 to 35 mm It seemed quite probable that a vessel of this nature is a tentorial branch of the siphon identified in our anatomical study Vessels of this type are shown in Fig 10

The indication for angiography in many of these cases has been subarachnoid haemorrhage The vessel has however been seen also in cases in which there has been no clinical suggestion of vascular abnormality It is difficult to know the significance of its appearance at angiography with our present rather

limited knowledge of this type of vessel It seems probable, however that it may be seen in normal cases (note the relatively large size of the vessel in the anatomical preparations from the normal cases in Figs 8 and 9) On the other hand if the vessel can be followed for a longer distance than 4 cm, and if it is unusually wide a pathologic lesion is probable

From what has been said concerning the vascular supply of the tentorial and basal dura it seems reasonable to assume that not only tentorial meningiomas but similar tumours originating from the dura of the middle fossa and adjacent parts of the anterior and posterior fossae should obtain part of their blood supply from the siphon Vessels from the siphon to sphenoidal ridge meningiomas and meningiomas of the posterior portion of the anterior fossa seem to be difficult to demonstrate partly because such vessels are hard to differentiate from branches of the anterior and middle cerebral artery Sphenoidal ridge meningiomas are also often somewhat sparsely vascularized Our experience with meningiomas originating from the floor of the middle fossa is very limited In one case of such a meningioma the tumour was found at operation to be richly supplied although only from its dural attachment Vessels to the tumour from the anterior meningeal branch of the ophthalmic artery could be demonstrated at angiography but no definite supply from the siphon was evident

SUMMARY

The supply of the tentorial and basal dura in the neighbourhood of the sella by two vessels arising from the cavernous portion of the internal carotid artery is described Such vessels are most often but not always too small to be demonstrated at angiography but may be of significance when contributing to the vascular supply of meningiomas and vascular malformations An investigation into the topography and distribution of these vessels is reported

ZUSAMMENFASSUNG

Zwei Blutgefasse die aus dem kavernosen Teil der Arteria carotis entspringen und das Tentorium und die basale Dura in der Nahe der Sella versorgen werden beschrieben Diese Blutgefässe sind meistens aber nicht immer zu klein um bei der Angiographie sichtbar zu werden Sie konnen aber dann gut gesehen werden wenn Meningiome oder Gefassmissbildungen vorhanden sind Die Arbeit klart die Anatomie dieser Gefasse

RÉSUMÉ

Les auteurs décrivent l irrigation de la dure mere de la tente et de la base au voisinage de la selle par deux vaisseaux venant de la portion intracaverneuse de l artere carotide intern Ces vaisseaux sont le plus souvent mais pas toujours trop fins pour être visibles par angiographie mais ils peuvent presenter de l intéret quand ils contribuent a la vascularisation de meningiomes et de malformations vasculaires Les auteurs presentent les résultats de leurs recherches sur la topographie et la distribution de ces vaisseaux

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INTRODUCTION OF A SOFT CANNULA INTO THE CAROTID ARTERY BY DIRECT PERCUTANEOUS PUNCTURE

by

PEKKA SOILA

Short cannulas may be introduced into parenchymatous organs and vessels by direct percutaneous puncture (MASSA et coll 1950 SELDINGER 1957, BARR 1959 1961) Although several materials have been used for the tubes the advent of polytetrafluorethylene (PTF) known by the brand names Tef lon (Du Pont) or Fluon (Imperial Chemical Industries), has greatly promoted various practical applications of this technique particularly in the puncture of vessels The preparation of the cannula from PTF tubing has earlier been de scribed in detail (SOILA 1962) a puncture of the carotid artery requires special consideration and is dealt with in this paper

Owing to the composition of the cannula needle combination the length of the cannula is primarily limited by that of the needle The length further more is reduced in cases in which a stop cock is attached to the instrument prior to the puncture this refinement however greatly facilitates an elegant completion of the puncture

The length of the cannula for a carotid puncture is further reduced by cer tain important practical factors Since the utmost care must be exercised in the perforation of the carotid artery the cannula should be about 10 mm short

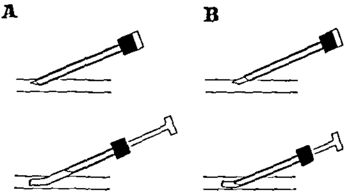
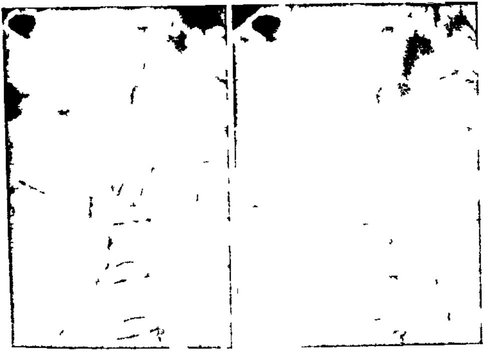


Fig 1 A — Illustration of principle of direct percutaneous puncture The cannula is of maximum length reaching to the bevel of the needle B — The cannula is about 1 cm shorter than the needle and thus unnecessary injury to the vessel is avoided if the puncture should be unsuccessful

er at the tip than the needle itself In the course of the puncture the position of the needle within the lumen of the catheter must be secured before the cannula is slid into the artery Should the cannula be the same length as the needle unsuccessful perforation of the vessel would cause unnecessary injury to the vessel, viz by the needle and catheter together (Fig 1) There are several types of needles in use for carotid puncture at the present time and of these the Jensen needle seems to be particularly suitable This needle is *some 15 cm long, and since a length considerably less than* this suffices for placing the cannula in the correct position within the lumen of the vessel, and even for further selective catheterisation of the internal carotid artery, the use of a cannula shorter at the tip than the needle is strongly recommended

The puncture itself is made as follows After cleansing of the skin at the site of the planned puncture, and the administration of local anesthesia a preparatory perforation of the skin should be made over the vessel after it has been located by palpation The skin in this region is rather tough, probably owing to its being exposed to the atmosphere and because of the constant movements of the neck Either puncture of the common carotid artery, or of the internal carotid artery, may then be attempted, according to the diagnostic requirements

The needle cannula should then be introduced through the hole in the skin As is customary in carotid punctures the needle should be kept continuously open by flushing with normal saline, or a mandrin should be used As soon as the vessel is perforated, the typical arterial blood flow indicates the correct position of the needle tip within the lumen The cannula may then be carefully slid into the vessel and the blood flow will confirm its position After flushing with saline the stop cock should be closed in anticipation of the



a b

Fig 2 a) Cannula in the common carotid artery b) The cannula is pushed upward into the internal carotid artery

further steps to be taken In contrast to the rather steep direction of the puncture needle as practised in many centres of neuroradiology, it is recommended that the vessel should be approached with the needle catheter at a rather small angle The cannula is then more securely and readily brought into the vessel than is the case after a steep direction of puncture Perforation of the opposite wall of the vessel must obviously be avoided

Polytetrafluorethylene in the form of tubing about 1 mm in diameter and 0 2 mm thickness is rigid enough to allow some manipulation to move it up from the common carotid artery into the internal carotid artery (Fig 2) However such a procedure will be successful only if the puncture as suggested above is made at a small angle On the other hand no spasm or other undesirable effects have been noted after a puncture of the internal carotid artery

Discussion

The main applications of the introduction of a Teflon cannula into the carotid artery will probably be found in combination with advanced methods of neuroradiology Repetitions of injections and changes in projection in

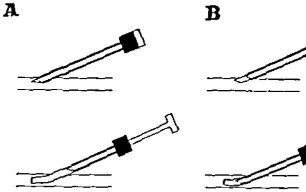


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RADIOGRAPHY OF ATHEROMATOUS DISEASE INVOLVING THE EXTRACRANIAL ARTERIES AS SEEN AT POSTMORTEM

by

BENNETT M STEIN WM F MCCORMICK, JESUS N RODRIGUEZ and JUAN M TAVERAS

Angiography of the entire extracranial vascular system concerned with cerebral blood supply is being performed on an increasing number of patients The improved surgical and medical techniques devised to deal with obstructive lesions of these vessels demand an accurate evaluation of the anatomy and significance of atheromatous processes occurring in these vessels

In spite of stimulated interest in this problem from a clinical standpoint there has been a dearth of information regarding the correlation of changes seen on angiograms with the pathologic processes seen at postmortem

MARTIN et coll (1960) in a thorough study of arteriosclerosis of these vessels recently reported a 24 % incidence of significant stenotic disease in individuals without neurological deficit Similarly FISHER (1954) in a study primarily of the carotid arteries in 432 unselected postmortem examinations found 45 cases with vascular occlusion and a 1 6 % incidence of occlusion without neurologic symptoms SAMUEL (1956) in another study primarily of the carotid arteries reported a 7 % incidence of stenotic lesions in asymptomatic individuals Because of this significant incidence of atheromatous disease

in asymptomatic individuals it has been difficult to interpret the clinical significance of atheromatous lesions involving these vessels. It has been especially difficult to determine the role of a single given lesion in the production of existing symptoms and signs.

HUTCHINSON and YATES (1957) have shed light on the nature and location of atheromatous processes occurring in the vertebral and carotid arteries. In a study of 83 autopsies by injection of radio-opaque gelatin into the extracranial vessels and subsequent anatomical study of the vessels, they found 40 cases with significant stenosis of the extracranial vessels. The carotid arteries were involved in 10 instances, the vertebral arteries in 7, and a combination of carotid and vertebral artery involvement occurred in 23 cases. STEWART et coll. (1935) have reported that the evaluation of atheromatous lesions in coronary arteries is more accurately accomplished by radiography of the distended vessels rather than cross sectional study of the vessels after routine fixation.

In order to clarify the relation of the extracranial atheroma to neurological symptoms and intracranial pathology and to evaluate the vessels in a condition most closely approximating the in vivo state, we have used postmortem angiography and special evaluation of the pathologic specimens.

Material and Methods. The material consisted of 130 postmortem examinations. Ninety cases were obtained from a general hospital and 40 cases from a hospital dealing primarily with cancer patients.

The cases were generally chosen from the older age groups, 114 of them being over the age of 50 years. The age and sex distribution are shown in Table 1. The proportion of male to female was about equal. The cases were unselected and consecutive wherever possible. The only tendency was to eliminate those cases under 40 years of age and those who died of intracranial abnormality unassociated with the atheromatous disease. The brains were examined in all but 25 instances.

An angiographic technique was used to completely evaluate the arteries concerned with cerebral blood supply from the aortic arch to the circle of Willis. The angiographic changes were confirmed by the removal and special preparation of the pertinent pathologic vessels. Our primary purpose was to

Table 1

Analysis of 130 postmortem examinations

Cases emanating from	40—50 years		50—60 years		over 60 years	
	Male	Female	Male	Female	Male	Female
General Hospital (90 cases)	4	7	10	10	29	30
Cancer Hospital (40 cases)		5	2	5	14	14
Totals	16		27		87	

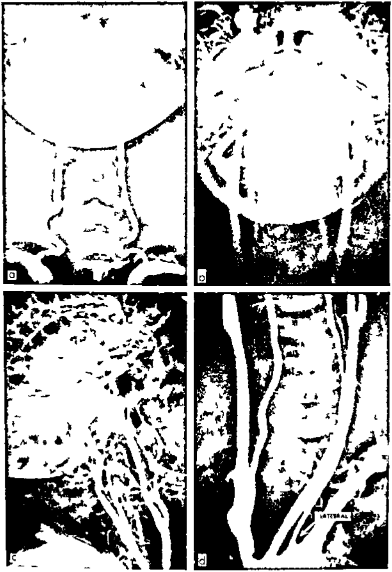


Fig 1 a) Anteroposterior view of the subclavian injections demonstrating the junction of the subclavian and vertebral arteries the intraosseous portions and intracranial portions of the vertebral arteries uniting to form the basilar artery b) Anteroposterior view of the carotid system showing the common carotid stem sinus and course of the internal carotid artery to its bifurcation c) Stereoscopic off lateral view demonstrating again the carotid system in another projection d) Anteroposterior view of the aortic arch demonstrating the origin of the great vessels

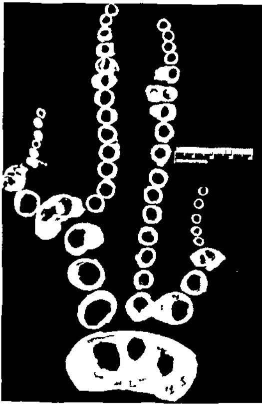


Fig 2 Cross sections of vessels removed at post mortem after distention fixation

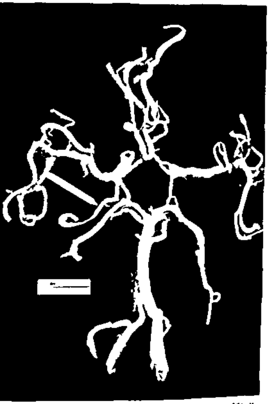


Fig 3 Completed dissection of the circle of Willis and its major ramifications

determine the location and extent of atherosclerotic stenotic lesions involving these vessels However, in the process of this study other facets concerning anomalies and anatomical variations in the course of these vessels were also evaluated

To obtain *roentgenograms of the appropriate vessels* the carotid and vertebral subclavian systems were isolated during the postmortem examination *The vessels were then injected with a viscid mixture of 40 % potassium iodide* in Karo syrup (supplied by Corn Products Inc , New York) This mixture has the advantage of being water soluble, facilitating removal and is viscid enough to produce intraluminal pressure approximating the in vivo distention of these vessels The 40 % concentration was chosen to produce an optimum degree of "translucency" of the injected vessels and yet useful density *We had previously* experimented with concentrations ranging from 5 % to 60 % A series of five roentgenograms comprising anteroposterior projections of the aortic arch carotid and vertebral arteries and stereoscopic off lateral roentgenograms of the carotid arteries were taken in every case The anteroposterior projection of the vertebral arteries is represented in Fig 1a Demonstration of the upper end of the basilar artery and its ramifications was not always certain, due to the

projection and the technique In Fig 1b the anteroposterior projection of the carotid system with a base view of the skull is shown, this is the best single projection for our purpose in demonstrating the internal carotid arteries The middle cerebral artery is moderately well outlined but the anterior cerebral arteries are not always well shown due to the projection Fig 1c represents a stereoscopic off lateral projection of the common and internal carotid arteries especially taken to better bring forth the carotid sinus and siphon and Fig 1d is an anteroposterior projection of the aortic arch In this particular case the left vertebral artery is seen to arise directly from the arch an anomaly seen in 6 % of the cases

Subsequent to angiography, by continuing our dissection of the vessels it was possible to palpate and inspect the entire aortic arch the vertebral arteries to their intraosseous portion and the carotid arteries to 3 cm above the carotid sinus The aortic arch the initial portion of the vertebral arteries and the intracranial portion of the internal carotid artery were removed in all cases The entire vertebral artery in the neck was removed in only a few special cases The films were immediately developed If any radiographical lesions were noted or suspected by palpation of the vessels the carotid arteries were removed to the base of the skull The specimens removed were prepared for cross sectional study (see Fig 2) by a special method of distention fixation described in detail elsewhere (McCormick and Stein 1962) This minimized the shrinkage artifact which is generally produced with routine fixation methods whereby the eccentric atheromatous lesions tend to assume a greater proportion of luminal stenosis than is actually the case The brains were fixed in 10 % formalin for 14 days The vessels at the base of the brain were then carefully dissected free well into their smaller ramifications as shown in Fig 3 The vessels were cross sectioned and atheromatous lesions recorded as to their longitudinal extent and percentage stenosis

In evaluation of the aortic arch and branches the carotid system to the carotid siphon and the vertebral system to the basilar artery 50 % stenosis measured from the roentgenograms was arbitrarily chosen as the dividing line between significant and non significant atheromatous involvement of a vessel Lacking data on the changes in cerebral blood flow occasioned by varying degrees of stenosis in different locations of the extracranial and intracranial circulation, it was felt that this subdivision gave the best overall representation of the severity of the disease processes without however an exact physiologic basis

Results

Thirty six cases representing 28 % of the 130 total autopsies had 50 % or more atheromatous stenosis of one or more of the extracranial and/or intracranial vessels The percent stenosis was measured in gradations of 10 % from the roentgenogram since the pathologic specimens from the initial phase of

this study were fixed in the routine fashion and were prone to exhibit fixation shrinkage artifacts The majority of the stenoses involved 50 to 80 % of the vessel lumen There were only 6 examples of vessel occlusion in the group of 36 showing an abnormality, an incidence of 4 6 % of the total autopsies studied

The material may be analyzed in a number of ways

A From the aspect of symptomatology of 121 cases without neurologic symptoms, there was a 22 % incidence of significant vascular stenosis Of the 9 individuals with symptoms, all (100 %) had significant arterial stenosis although in two cases it primarily involved the intracranial vessels

B The group of 36 cases with significant vascular stenosis can be divided according to the incidence of infarction or neurologic symptoms of cerebral vascular disease, as in Table 2 which is a composite chart of the 36 cases Three

Table 2

ANALYSIS OF CASES WITH 50° OR MORE STENOSIS

	Clinical Picture	Cerebral Lesion	Intracr Vessels	Vert Art R	Vert Art L	Car Art R	Car Art L
1	Str	Infar	Mild	◐	○	◐	◐
2	Str	I far	Mark.	◐	○	◐	◐
3	Str	Infar	Mod	○	○	◐	◐
4	Str	Inf	Ma k.	○	◐	◐	◐
5	Str	I fa	Mark.	○	◐	◐	◐
6	Str	Infar	Mild	◐	○	●	◐
7	Str	Infa	Mod	◐	○	◐	◐
8	Str	I fa	Ma k	○	◐	○	○
9	O M.S	Infar	Mark	◐	◐	◐	◐
10	Nor	I f	Mark	○	○	◐	◐
11	No	I far	Mark	◐	●	◐	◐
12	Nor	Infa	Mild	○	○	◐	◐
13	No	I far	Mild	○	◐	○	◐
14	Nor	I f	Ma k	○	○	○	○
15	No	N ne	M d	◐	○	○	○
16	Nor	No e	Mild	◐	◐	○	○
17	No	N ne	Mild	◐	◐	○	○
18	Nor	None	Mild	◐	◐	◐	○
19	No	None	Mild	○	◐	◐	◐
20	Nor	N n	M k	◐	○	○	○
21	No	None	Mod	○	○	◐	○
22	Nor	None	Mild	○	○	○	●
23	No	No e	Ma k.	○	○	◐	◐
24	No	N B	—	○	○	◐	◐
25	Nor	None	Mild	○	○	◐	◐
26	N	N B	—	○	○	◐	◐
27	Nor	N ne	Mild	◐	◐	◐	◐
28	Nor	N B	—	◐	●	◐	●
29	N r	None	Mod	◐	◐	●	◐
30	Nor	None	Mark	◐	◐	◐	◐
31	Nor	No e	M rk.	○	◐	◐	◐
32	Nor	None	Mark.	◐	◐	◐	◐
33	Nor	None	M k	◐	◐	◐	◐
34	N	None	Mod	◐	○	◐	◐
35	Nor	No e	Mild	○	○	◐	○
				(Subclavian involvement)			
36	Nor	None	Mark.	○	○	○	○

(Key to abbreviations in the table)

Str — Stroke

O M S — Organic mental syndrome

Nor — Normal

Infar — Infarction

N B — No brain permission

Mark — Marked

Mod — Moderate

The degree of intracranial atheroma was rated mild under 25 s enosi moderate under 50 s eno is marked over 50 stenosis includ ng occl n

The blacked areas represent degree of atheromatous s enosis in the corresponding extracranial vessels



Fig 4 Anteroposterior projection of the vertebral arteries showing stenotic lesions at their origins more marked on the left side



Fig 5 Off lateral projection of the carotid arteries showing severe stenoses in the region of the sinuses

categories of cases were devised from this chart Those with cerebral infarcts and symptoms (Cases 1 to 9) those with asymptomatic infarcts (Cases 10 through 14), and the latter part of the chart, Cases 15 to 36 those without infarcts or symptoms Cases 14 and 36 were solely intracranial atheroma and Case 35 was primarily left subclavian artery involvement

1 In the first group of 9 cases symptoms and clinical manifestation were generally not severe consisting of mild hemiparesis or hemianopsia and in one case intermittent symptoms of basilar artery insufficiency In only one of this group did a massive cerebral vascular accident occur the result of thrombotic occlusion of one carotid siphon during the immediate postoperative period of urologic surgery The remainder of the infarcts were small

2 The second group of 5 cases was one in which small infarcts were present in the brain without clinical manifestations There was no significant difference between this and the first group in the nature and extent of the arteriosclerotic lesions The only difference and this was a slight one was in the size of the infarct the ones in the asymptomatic group tending to be smaller than in the symptomatic group The infarcts tended to be small and were under 3 cm in size except in the one case mentioned of massive cerebral infarction



a b

Fig 9 a) Anteroposterior projection of the vertebral arteries Extreme degree of tortuosity b) Anteroposterior projection of the anomalous origin of the great vessels from the aortic arch The right vertebral artery arises directly from the right common carotid artery (arrow) The other arrows indicate the retro-esophageal course of the right subclavian artery and the direct origin of the left vertebral artery from the aortic arch

carotid artery involvement (see Fig 5) 3 of these having severe intracranial atheroma as well (30 %) There were 14 cases with stenotic lesions of both the vertebral and carotid systems (Fig 6) and in eight of these severe intracranial atheroma was present (57 %) In 4 cases the atheromatous process was primarily intracranial In one case the process was confined to the subclavian arteries It appears from this small group that there is a higher incidence of intracranial stenotic lesions when involvement of both the carotid and vertebral arteries is present as might be expected

Radiographically the atheromatous lesions seen in the extracranial vessels were generally limited to certain areas The most common site was the carotid sinus, next in frequency was the vertebral subclavian junction and to a lesser extent the carotid siphon and subclavian arteries The longitudinal extent of the lesion seen at the carotid sinus was greater than that seen at the vertebral subclavian junction (compare Figs 4 and 5) The lesions seen in the latter

region were often of diaphragmatic nature due to the fact that the atheromatous process was eccentric, patchy and primarily involving the subclavian side of the junction Conversely, the lesions seen in the carotid sinuses frequently extended for short distances in either direction of the vessel It was unusual, however, to see the stenotic areas extending far in the direction of the internal or the common carotid arteries Diffuse involvement existed in only a few cases and then the internal carotid artery was relatively spared (see Fig 7) Stenotic lesions were rarely seen in the petrous portion of the internal carotid artery or the intraosseous portion of the vertebral artery The carotid siphon was involved with atheroma to a lesser extent than the carotid sinuses

Because of the eccentric nature of the atheromatous processes seen in the carotid sinuses the lesion often appeared far less extensive in one plane than it did in the corresponding perpendicular plane (see Fig 8) The importance of multiple views to fully evaluate lesions in this area was apparent in a number of cases For this reason both anteroposterior and lateral stereoscopic views were taken in all cases

Tortuosity was seen frequently in the internal carotid artery in its cervical as well as intracavernous portions Similarly in the vertebral artery tortuosity was seen on occasions in the intraosseous portion (see Fig 9a) In none of these cases was there evidence of a constricting lesion to suggest atheromatous processes at the site of maximum angulation No symptoms were present in these patients which could be attributed to diminished blood flow through these vessels

A number of anomalies were seen the most common of which was the origin of the left common carotid artery from the right innominate artery This was present in 29 cases Direct origin of the left vertebral artery from the aortic arch was seen in 8 cases (6 %) (Fig 1d) Two cases were found in which the right subclavian artery originated as the last branch of the aortic arch and took a retro esophageal course In one of these the right vertebral artery originated from this anomalous right subclavian artery In the other case the right vertebral artery arose directly from the right common carotid artery in conjunction with a direct origin of the left vertebral artery from the aortic arch (Fig 9b)

Conclusions

In postmortem examination of vessels the problem of fixation shrinkage by which atheromatous processes assume greater proportions than is actually the case in vivo has been realized by us in this study and has been well documented by previous authors To overcome this problem it is felt that pressure angiography simulating in vivo distention of the vessel combined with fixation of the pathologic specimens in their normally distended state is the best way to evaluate atheromatous processes involving the cerebral blood supply This technique is readily adaptable to the extracranial cerebral vascular system but

is not fully practical in the intracranial vascular system because of the ramifications and minuteness of the vessels

Complete angiographic evaluation of stenotic lesions in the extracranial vessels requires multiple views, especially projections at right angles to one another

The cerebral vascular supply in 130 consecutive and unselected postmortem cases has been evaluated with regard to anomalies anatomical variations in the course of these vessels and the presence and magnitude of atheromatous lesions, 88 % of the cases over 50 years of age An incidence of 28 % (36 cases) exhibited 50 % or more atheromatous stenosis of one or more of the vessels studied Four cases exhibited involvement primarily of the intracranial vessel the rest had involvement of both extra and intracranial vessels to varying degree

There was a 22 % incidence of occlusive disease in the asymptomatic group of 121 cases, and a 100 % incidence of occlusive disease in the relatively small group of 9 asymptomatic cases

In the group of 36 cases with occlusive disease there were 14 cases with cerebral infarction In comparing these with 22 cases without cerebral infarction, we have made the following observations (see Table 2)

1 The degree of stenosis of the intracranial vessels was greater in the group with infarctions

2 Occlusion of the extracranial vessels could occur without infarction in which instance the occlusion usually lay closer to the aortic arch (Occlusion of the carotid siphon in one case led to massive infarction)

3 The severity of involvement of the extracranial vessels by atheromatous lesions was somewhat greater in the group with infarcts than in those without However severe atheroma could involve the extracranial vessels and not result in cerebral infarctions or symptoms

4 The most significant factor was the incidence of severe intracranial atheroma which was greater in the group with infarcts This somewhat outweighed the significance of atheromatous involvement of the extracranial vessels which was also greater in the infarct group

Therefore, infarcts were in general produced by a combination of intracranial and extracranial atheroma

The atheromatous lesions had a predilection for certain areas namely carotid sinus vertebral subclavian junction and carotid siphon, in order of frequency The intervening portion of the parent vessel was usually completely free of atheroma The most common site of involvement was the carotid sinus. Lesions in this latter region were more extensive than those seen at the vertebral subclavian junction The most common situation was to have involvement of both the carotid and vertebral systems, which often was associated with significant atheroma of the intracranial vessels

A series such as this gives some insight into the complexities and pitfalls of

radiographic and pathologic studies of cerebral arteriosclerosis both of the extra and intracranial vessels However further correlative studies are necessary

SUMMARY

One hundred and thirty postmortem cases were studied by means of angiography and evaluation of pathologic specimens The purpose was to study the location incidence and possible significance of atheromatous lesions occurring in the major arteries supplying the brain A 22 % incidence of stenosis in asymptomatic cases and a 100 % incidence in the symptomatic cases were found The most significant factor in cerebral infarction was the combination of intra and extracranial atheroma

ZUSAMMENFASSUNG

Es wurden 130 postmortem Falle mittels Angiographie und Untersuchung des pathologischen Praparates studiert Es war die Absicht die Lokalisation und etwaige Bedeutung von atheromatosen Veranderungen der grosseren Hirnarterien zu studieren. Bei den asymptomatischen Fallen fand man stenotische Veranderungen in 22 % bei den Fallen mit Symptomen hingegen in 100 % Der bedeutendste Befund bei cerebralem Infarkt war die Kombination von intra und extrakraniellem atheroma

RÉSUMÉ

Les auteurs ont étudié par angiographie post mortem et par examen des pieces necropsiques chez cent trente sujets les lésions atheromateuses de la partie extracranienne des arteres qui irriguent le cerveau pour établir la fréquence des diverses localisations et l importance des lésions Ils ont trouvé une sténose dans 22 % des cas asymptomatiques et dans 100 % des cas ayant presente des symptomes Le facteur le plus important du ramollissement cérebral est l association d athérome intra et extracérébral

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ANGIOGRAPHIE CAROTIDIENNE ELECTIVE DANS LE DIAGNOSTIC ET LE TRAITEMENT DES ANGIOFIBROMES NASOPHARYNGIENS

par

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Les moyens cliniques permettent habituellement le diagnostic de nature des angiofibromes nasopharyngiens mais ils sont généralement insuffisants pour définir leur extension Des examens complementaires sont donc nécessaires pour preciser ce point du diagnostic puisque de toute évidence l efficacité du traitement qui est chirurgical et radiotherapique est conditionné par la connaissance prealable du volume et des prolongements de la tumeur Les investigations complementaires relevent du radiodiagnostic Elles se sont limitées jusqu'à present à l examen direct du squelette cranio facial et du cavum, en utilisant des techniques standard ou tomographique Les renseignements obtenus se sont révélés parfois insuffisants, incomplets ou trompeurs

En nous basant sur le fait que ces tumeurs sont très vasculaires, developpées dans un territoire irrigué par l artere carotide externe, mais accolées à la base du crane, nous avons applique a leur etude les techniques d examen angiographique par ponction percutanée de l artere carotide interne et externe Le but de ce travail est de démontrer l intérêt de cette exploration tant au point de vue du diagnostic qu au point de vue du traitement

Analyse de la litterature Les angiofibromes nasopharyngiens sont rares Pour tant, ils ont constitue l un des sujets principaux traités au Congres International O R L de Berlin en 1911 et, depuis 1923, n ont pas suscite moins d une vingtaine de publications importantes dans lesquelles le materiel atteint parfois 70 cas (TAPIA ACUNA 1956)

Ce sont les aspects histologique, pathogenique, étiologique therapeutique et clinique de la lesion qui ont surtout retenu l attention des chercheurs L aspect radiologique n a ete envisage qu accessoirement

Au point de vue histologique, ces lesions sont habituellement recouvertes d un épithelium cylindrique squameux ou corne Elles sont constituees par un stroma conjonctivo fibroblastique interpose entre des reseaux vasculaires tres abondants de 2 types (1) des veines et des arteres normales ou anormales (2) des vaisseaux a parois minces soit de gros diametre et du type lacunaire soit de petit diametre comme les capillaires On n y reconnait aucun elément cellulaire monstrueux comme dans les tumeurs malignes Elles se differencient des polypes vasculaires par l absence de canaux et de cryptes glandulaires

A cause de sa tendance spontanee a la regression beaucoup d auteurs dont OSBORN (1959) ont conteste le caractere neoplasique vrai de l angiofibrome nasopharyngien, d autant plus qu il se developpe toujours au meme endroit et toujours chez des sujets masculins ages de 10 a 25 ans HARMÉ (1959) le classe dans le groupe des reactions tissulaires hyperplasiques de nature essentielle ment fibro-angiomateuse et l assimile ainsi au granulome gravidique, a l histiocytome et a l hémangiome de la cloison nasale Il considere que son develop pement est determine par un facteur hormonal actif durant la puberte mais de courte duree Cependant des essais therapeutiques basés sur cette theorie deja ancienne n ont pas donne les resultats escomptes (FIGI & DAVIS 1950, AUBIN et coll 1956)

Actuellement le traitement classique est chirurgical et radiotherapique ou chirurgical seul, precede ou non par quelques seances d irradiation ou d in jection in situ d hydrocortisone (SALA & MEGIGHIAN 1956) En raison de la nature de ces traitements, une connaissance prealable approfondie du volume de la lesion et de ses prolongements apparait donc indispensable En effet tous les travaux font apparaitre que ces traitements ne sont pas generalement radicaux 50 % de ces tumeurs recidivent DELAVAN et aussi FERRERI pre tendaient que les tumeurs de petit volume avaient un meilleur pronostic que les autres Reprenant cette idee HARME analyse un materiel de 49 tumeurs avec 6 recidives sur 30 cas ou la lesion est limitee au nasopharynx et a la partie posterieure de la fosse nasale et 17 recidives sur 19 cas ou la tumeur cavaire ou non occupe la narine s étend aux sinus ou a la fosse ptervgo pala tine ou 2 ou 3 localisations a la fois Toujours selon cet auteur un autre facteur qui conditionne le pronostic est le point d attache de la tumeur Dans 17 cas ou l implantation est etalee au nasopharynx et à la region choanale il y a eu 12 cas de recidive tandis que dans 7 cas ou la lesion est implantee exclusive ment au plafond du nasopharynx aucune récidive n est observee

Il n est cependant pas facile avec des moyens cliniques simples d etablir ces caracteristiques d implantation et d'extension L'angiofibrome nasopharyngien se presente au clinicien sous l'aspect d une tumeur rougeatre de consistance assez ferme et tres hemorragique En se developpant vers l avant, il obstrue une fosse nasale et fait parfois irruption a travers la narine correspondante, il en resulte que la rhinoscopie antérieure est peu utile Quand la tumeur s'accroit vers le bas en direction de l oropharynx, la rhinoscopie posterieure ne peut renseigner sur une extension postero laterale de la masse

Si la voie chirurgicale transmaxillo nasale de Moure, ou de Rouge Denker, est preconisee dans les lesions de ce type c est parce qu'elle «permet un large acces sur la tumeur dont les caracteristiques de dimension, d implantation et d extension n ont pu etre precises avant l intervention» *(Radzimınski 1960)* Mais meme avec cette technique une partie de la tumeur peut echapper à l'exploration chirurgicale Il nous semble donc admissible de deduire que si ce sont les tumeurs de gros volume qui recidivent c est parce qu elles n ont pas ete detruites en totalite

Examen radiologique Une remarque preliminaire s impose en ce qui concerne l apport des examens radiologiques dans le diagnostic On ne trouve pas dans la litterature de tableau séméiologique caracteristique, tandis que la carence d examens radiologiques approfondis est frappante À cote de descriptions cliniques et chirurgicales tres fouillees, les descriptions radiologiques sont extremement sommaires et reposent le plus souvent sur un examen standard des sinus Lors de tels examens, la tumeur apparait comme une masse molle, opacifiant une fosse nasale Un voile couvrant le sinus maxillaire ou ethmoidal ne traduit pas necessairement l extension de la lésion a ces cavites sinusales qui peuvent etre le siege de lesions suppuratives banales (Gignoux et coll 1959)

Des examens tomographiques de la base du crane en position axiale ont ete realises et n ont montres aucune lesion osseuse dans un cas relate par Gignoux et coll ou la tumeur avait une grosse extension dans une fosse pterygo palatine Personnellement nous ne pensons pas que cette exploration seule suffit pour eliminer une lesion des constituants osseux regionaux

Pour Baclesse (1960), le diagnostic differentiel des angiofibromes nasopharyngiens d avec les tumeurs malignes du nasopharynx (fibrosarcomes, myxosarcomes et cylindromes) est base sur l existence de destructions osseuses qui caracterisent la malignite Cependant, Lismonde & Lepage (1959) ont rapporté l observation de 2 cas controles histologiquement et repris dans notre materiel ou les auteurs signalent sans assez y insister a notre avis, l existence de lesions osseuses importantes Cet elément du diagnostic differentiel ne semble donc pas avoir une valeur certaine

Aucun auteur ne signale l extension possible de la lesion a l interieur du crane

Enfin, l angiographie carotidienne n a jamais ete appliquee a l etude de ces tumeurs l angiographie de la carotide interne ne s appliquant qu a l etude des lesions intracraniennes, tandis que l interet de l angiographie de l artere carotide externe n est souligne que pour le diagnostic des lesions extra cere brales developpees a partir des enveloppes du cerveau (LINDGREN 1954, RUGGIERO & JAY 1958)

Analyse de notre materiel

Notre materiel comporte 3 cas dont 2 recidives

Cas 1 Masculin né en 1943 En 1956 le patient se plaint d une chute de l acuité visuelle de l œil gauche à évolution tout d abord cyclique suivie bientot d une exophtalmie progressive avec cécité complète Un peu après se déclenchent des épistaxis fréquents avec gonflements de la joue

Adressé au Service de Neurochirurgie (Pr CHRISTOPHE) le patient est confié au Service d O R L (Pr DESTRÉE) La rhinoscopie anterieure découvre une masse charnue rougeatre qui s insère dans la narine gauche entre le cornet moyen et la cloison En rhinoscopie posterieure la masse descend du plafond du cavum sur la portion postero-supérieure de la cloison et s étend sur toute la portion supérieure de la choane gauche

Une biopsie est pratiquée très hémorragique Le diagnostic histologique est celui d angiofibrome (Pr FIRKET) Le patient est alors envoyé au service pour une étude radiologique qui comporte un examen direct standard du crane de la face et des sinus ainsi qu un examen tomographique des orbites et des sinus Ces explorations montrent une masse molle qui envahit la fosse nasale gauche détruit la partie postérieure et interne du sinus maxillaire érode la fente sphénoidale le plancher de l orbite et la paroi inférieure du sinus sphénoidal

Apres un traitement radiothérapique intense (Pr DESAIVE) au cours duquel l enfant recoit 5 400 r le Pr CHRISTOPHE intervient par la voie de Moure La tumeur envahit la fosse pterygo-maxillaire elle a le volume d une petite banane et peut etre enlevée en totalité Les suites opératoires sont satisfaisantes Cependant 2 ans plus tard la tumeur récidive et au début de 1959 le patient est adresse au service pour une nouvelle exploration radiologique

Cas 2 Masculin né en 1946 Le patient est adressé au service en 1956 avec le diagnostic d angiofibrome obtenu par biopsie (Pr FIRKET)

La rhinoscopie antérieure démontre une tumeur occupant la narine gauche et envoyant un prolongement vers le méat moyen la rhinoscopie posterieure n a pu etre réalisee l enfant ne se pretant pas a la manœuvre A la diaphanoscopie le sinus maxillaire gauche était obscur (Service O R L Pr DESTRÉE) Une exploration radiologique directe standard et tomographique des sinus démontre une masse molle étendue de la choane gauche a la partie antérieure du nasopharynx La limite anterieure de la lésion ne peut être mise en évidence a cause d un tamponnement anterieur nécessité par les suites hémorragiques de la biopsie Par son pôle inférieur la masse repose sur le palais osseux et membraneux par son pole postéro-externe elle detruit partiellement l aile interne de l apophyse pterygoide tandis que vers le haut elle envahit la partie postérieure de l ethmoide et le sinus sphénoidal

Une première tentative d exérèse chirurgicale par voie nasale a du être abandonnée tant il est évident que la lésion ne peut être enlevée en totalité par cette voie d abord et aussi a cause d une hémorragie per opératoire abondante Quelques jours plus tard une nouvelle intervention est réalisée par la voie de Rouge Denker Cette fois le chirurgien a l impression d avoir enlevé toute la tumeur dont l extens on à l ethmoide posterieur le sinus sphénoidal



Fig 1 Cas 1 Examen tomographique de la base du crane a) Profil Masse molle appendue à la face inferieure du corps du sphénoide occupant le nasopharynx Le pole inferieur (↙) de la masse affleure la face dorsale du palais membraneux b) Face La lésion elargit la fente sphénoidale gauche et detruit (↗) la portion basale interne de la grande aile du sphenoide

et la fosse ptérygo maxillaire est confirmée, ainsi que les destructions osseuses mises en évidence par l examen radiologique

Le traitement chirurgical est complété par de la roentgenthérapie anti inflammatoire du cavum pendant un mois (service du Pr Desaive) Deux ans plus tard la lésion récidive occupant la partie gauche du cavum et se propageant vers la narine gauche C est à ce moment que le malade est confié une nouvelle fois au service pour exploration radiologique complète

Cas 3 Masculin né en 1947 La symptomatologie initiale datait de quelques mois La nature de la lésion n a pas éte immédiatement reconnue L enfant avait presenté quelques épistaxis peu importants Ultérieurement une obstruction progressive de la narine gauche est apparue en même temps qu un gonflement de la joue Comme il y avait un mouchage purulent et sanglant l hypothese d un processus inflammatoire sinusal infectieux avait été soulevée et un lavage de sinus fut réalisé après un examen radiologique démontrant une opacité du sinus maxillaire gauche C est un accident (quadriparésie brutale régressive en 2 jours) au cours de ce lavage qui a fait adresser le patient au Service d O R L (Pr Ledoux)

A la rhinoscopie antérieure la masse obstrue la partie posterieure de la fosse nasale gauche A la rhinoscopie posterieure la masse est appendue a la paroi supérieure du nasopharynx et atteint la choane gauche par le haut L aspect macroscopique de la lesion fait poser le diagnostic d angiofibrome En décembre 1960 le patient est adressé au service en vue d investigations radiologiques

Chez tous ces patients, nous avons realise des explorations radiologiques suivant un plan systematique

1° un examen standard du crane et des sinus,

2 un examen tomographique de face et de profil des sinus et de la base du crane,

3 une angiographie de l artere carotide externe du coté de la lésion

4° une angiographie de l artère carotide interne du meme cote

Resultats des examens directs

Cas 1 Une volumineuse masse molle est appendue au plafond du nasopharynx descendant vers le bas en arriere des choanes surtout developpée à gauche de la ligne mediane Le pole inférieur de la masse est régulièrement arrondi et descend au contact du palais membraneux (Fig 1a)

La tumeur s accompagne d importantes destructions osseuses Celles-ci ne sont cependant pas sensiblement plus marquées que lors du premier examen realisé en 1957 (cfr description précédente) Il faut cependant signaler l existence d une destruction partielle de la portion basale interne de l étage moyen gauche en arriere de l apophyse pterygoide (Fig 1b)

Cas 2 Une volumineuse masse molle accolee a la face inferieure du corps du sphenoide e prolonge dans l oropharynx son pole inférieur se situe 1 cm au-dessus de la face dorsale de la langue (Fig 2a) Vers le haut et vers l avant la masse occupe toute la fosse nasale gauche

Vers l arrière la tumeur détruit l apohyse pterygoide et la portion basale interne de l étage moyen (Fig 2b) Elle détruit aussi la fente sphénoidale en erodant la portion interne de la grande aile du sphénoide (Fig 2c)

Cas 3 Dans ce cas les examens démontrent également l existence d une masse molle appendue à la face inferieure du corps du sphénoide (Fig 3a) à gauche de la ligne mediane La masse a un volume relativement petit Vers le haut elle atteint la partie supérieure de la choane gauche mais n occupe pas la fosse nasale

Les lesions osseuses sont peu importantes Elles consistent exclusivement en une érosion de la portion interne orbitaire de la grande aile gauche du sphénoide (Fig 3b) de telle manière que la fente sphenoidale apparait fortement élargie La portion basale de l étage moyen ainsi que l apophyse ptérygoide gauche apparaissent intactes (Fig 3c)

Commentaires Dans tous les cas les examens demontrent une masse molle appendue au plafond du nasopharynx La tumeur est volumineuse dans les 2 cas de recidive et a un volume apparemment tres limite dans le 3e cas

Chaque fois la masse determine des destructions osseuses qui permettent de preciser son extension Dans les 2 cas de recidive la destruction de la portion basale interne de l etage moyen de la base du crane permet de soulever l hypothese d une extension intracranienne de la lesion ce qui n est pas a envisager dans le 3eme cas ou la base du crane apparait intacte Alors qu une symptomatologie clinique oculaire n est presente que dans un seul cas (Cas 1) une erosion de la levre externe de la fente sphenoidale du cote de la lésion existe dans les 3 cas

Resultats des examens angiographiques

Cas 1 Angiographie de l artere carotide externe gauche Le calibre de l artère carotide externe et de sa branche terminale l artère maxillaire interne est très important Dans le territoire correspondant topographiquement à la mass molle mise en évidence par l examen direct il apparait dès le stade artériel une vaste zone de vascularisation pathologique Cette zone s étend à la totalité du sinus maxillaire gauche a la part e posterieure de la cavité orbitaire et est surtout developpée à la face inféri ur de la voute du nasopharynx (Fig 4a) Elle intéresse aussi le sinus sphenoidal La circulati n dans ce territoire a des caractéristiques de circulation



a



b



c

Fig 2 Cas 2 Examen tomographique de la base du crane a) Profil Le pole inferieur (↗) de la masse qui occupe le nasopharynx descend dans l oropharynx et s arrete un peu au dessus de la face dorsale de la langue b) Face La tumeur qui occupe la fosse nasal gauche et la portion médiane et laterale gauche du naso et de l oropharynx, s etend au sinus sphénoidal (↗) et detruit la partie interne de la base de l étage moyen gauche (↗) c) Face p a d mi axiale La fente sphenoidale gauche est elargie par suite d une destruction ( ) de sa levr externe constituée pa la grande aile du sphénoide

normale au stade *artériel* les vaisseaux sont du type artériolaire puis le contraste diffuse dans toute la tumeur au stade capillaire Il n y a pas de fistule artério-veineuse La branche principale de la tumeur est l artère maxillaire interne mais l artère faciale intervient également dans la vascularisation tumorale

Angiographie de l'artere carotide inter e Au stade artériel il apparaît une zône de vascularisation pathologique à la face pc trale externe du sinus caverneux Cette zône a un volume c est nourrie par hes vestigiales de la portion intracaverneuse du siphon (*Fig* 4b)



a b c

Fig 3 Cas 3 Examen tomographique de la base du crane a) Profil La tumeur est relati ement peu volumineuse Elle est appendue au plafond du nasopharynx et atte nt vers le haut et vers l avant (↗) la portion haut de la choane gauche b) Face p a demi axiale Elargi ement de la fente sphenoi dale gauche causee par une éros on de la portion adjacente de la grande aile du sphenoide (↗) c) Face La base de l apophyse ptérygoide est intacte (↗) d même que la portion adjacente de l étage moyen

Cas 2 Angiographie de l'artère carotide externe gauche L artere carotide externe et l artere maxil laire interne ont un calibre plus important que celui que l on observe d habitude La masse molle décrite à l examen direct apparait extremement vascularisée Elle est constituée par un réseau très serré d artérioles apparaissant dès le stade artériel Il n y a pas de fistule artério-veineuse les néovaisseaux s étendent a l étage moyen de la base du crane (Fig 5a)

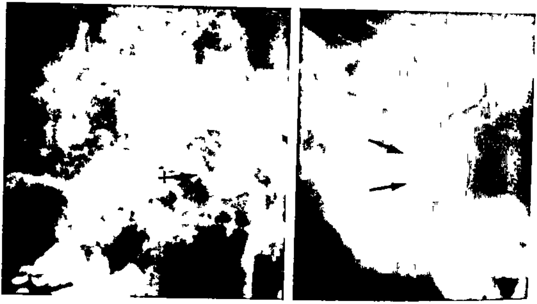
Angiographie de l artere carotide interne gauche L artere ophtalmique intervient dans la vasculari sation de la tumeur Celle ci s étend a la partie postérieure et interne de la cavité orbitaire et a la partie interne de l étage moyen de la base du crane (Fig 5b)

Cas 3 Angiographie de l artere carotide externe gauche Dès le stade arteriel il apparait une zone de vascularisation importante distribuée en arriere du sinus maxillaire gauche et de la choane gauche Cette zone s étend vers l arrière a l etage moyen de la base du crane (Fig 6a) Les néovaisseaux et la circulation ont les memes caracteres que ceux decrits dans les Cas 1 et 2

Angiographie de l artere carotide interne gauche Des le stade arteriel il apparait une zone de vascularisation pathologique s etendant à cheval sur la portion interne de l etage moyen de la base du crane et en dessous du plafond du nasopharynx nettement en arriere du territoire tumoral irrigué par l artère maxillaire interne Les vaisseaux sont du type artériolaire distribués suivant un réseau extremement serre (Fig 6b)

Commentaires Dans les 3 cas l angiographie carotidienne demontre le carac tere angiomateux de la masse molle mise en evidence par les examens directs Elle n apporte pas de renseignements complementaires substantiels sur l ex tension de la tumeur si ce n est son prolongement a l étage moyen dans les 3 cas y compris celui ou la base du crane paraissait intacte (Cas 3)

Ces explorations démontrent que si l artere carotide externe intervient de façon preponderante dans la vascularisation tumorale l artere carotide in terne y contribue aussi



a b



c

Fig 4 Cas 1 a) Angiographie de l artère carotide externe gauche (profil stade arteriel) L examen demontre le caractère angiomateux de la masse molle mise en evidence par les examens directs La tumeur est principalement nourrie par l artere maxillaire interne (/) et l artere faciale (↗) b) et c) Angiographie de l artere carotide interne gauche face et profil stade arteriel Par l intermédiaire de branches vestigiales de la portion intracaverneuse du siphon l artere carotide interne nourrit une partie de la tumeur qui s etend le long de la face laterale (×) et posterieure (/) du sinus caverneux

Conclusions

1° Dans nos 3 observations, le diagnostic d angiofibrome, c est a dire le diagnostic de nature, avait ete fait par le clinicien avant les explorations radiologiques

2 Dans les 3 cas les moyens cliniques simples n avaient pas permis un diagnostic suffisant en ce qui concerne l extension de la tumeur



a



b

Fig 5 Cas 9 a) Angiographie de l artere carot de externe gauche profil stade arteriel L examen demontre le caractère angiomateux de la tumeur qui s etend à l etage moyen de la base du crane (/) b) Angiographie de l artère carot de interne gauche profil stade arteriel L artere carotide interne contribue abondamment à la nutrition de la tumeur qui s etend à cheval sur le nasopharynx ( ) et l etage moyen (×) de la base du crane

3° Dans les 3 cas, les examens directs ont mis en evidence une masse molle du cavum plus ou moins étendue et chaque fois accompagnee de lesions osseuses importantes qui permettent de preciser l extension de la lesion Les caracteristiques d extension ne sont cependant pas completement definies par les examens directs

4 L existence de lesions osseuses destructrices occasionnees par ces tumeurs ont un interet dogmatique évident En effet les angiofibromes du cavum sont des tumeurs benignes tandis que l existence de lesions osseuses constituent un critere radiologique essentiel pour caracteriser la malignite d une masse molle developpee dans le cavum

5 *Dans les 3 cas la nature angiomateuse de la tumeur a ete demontree* par l angiographie carotidienne Ce renseignement a un interet capital car il rend la biopsie inutile En effet ces tumeurs sont a distinguer des tumeurs malignes du cavum, les fibrosarcomes les myxosarcomes et les cylindromes tumeurs malignes qui ne sont pas vascularisees Cette contribution au diagnostic des angiofibromes nous parait essentielle En effet la biopsie est dangereuse dans ces tumeurs parce qu elle entraine frequemment des hémorragies extremement graves



a



b



c

Fig 4 Cas I a) Angiographie de l'artère carotide externe gauche (profil stade artériel) l'examen démontre le caractère angiomateux de la masse molle mise en évidence par les examens directs La tumeur est principalement nourrie par l'artère maxillaire interne (↗) et l'artère faciale ( ) b) et c) Angiographie de l'artère carotide interne gauche face et profil stade artériel Par l'intermédiaire de branches vestigiales de la portion intracaverneuse du siphon l'artère carotide interne nourrit un glomus partie de la tumeur qui s'étend le long de la face latérale ( ) et postérieure (↗) du sinus caverneux

Conclusions

1° Dans nos 3 observations, le diagnostic d'angiofibrome, c'est à dire le diagnostic de nature avait été fait par le clinicien avant les explorations radiologiques

2° Dans les 3 cas, les moyens cliniques simples n'avaient pas permis un diagnostic suffisant en ce qui concerne l'extension de la tumeur

8° En demontrant la branche arterielle nourriciere principale de ces tumeurs l angiographie de l artere carotide externe permet l application aux angiofibromes du nasopharynx de nouvelles techniques de chimotherapie anti cancereuse par voie arterielle (STEHLIN et coll 1960 WOODHALL et coll 1959 CREECH et coll 1959) Nos 3 cas ont ete traites par perfusion intra arterielle d yperite a l azote sous conditionnement circulatoire normal (Pr DELAIVE) Les 2 cas de recidive ne se pretaient plus de toute evidence a un traitement chirurgical ou radiotherapique classique en raison des traitements anterieurs et de l extension tres importante de la lesion

La methode utilisee, appliquee par LEBRUN et HENRY (1960) dans les formes tres graves de cancer bucco-pharyngien (en association avec la radiotherapie conventionelle) consiste a introduire un catheter dans l artere carotide externe denudee au cou L extremite du catheter est guidee sous controle arteriographique jusqu a l origine de l artere maxillaire interne Ensuite le catheter est laissé en place et sous perfusion continue lente de serum glu cose, des doses fractionnees d yperite sont injectees en un ou plusieurs jours Chez nos patients des doses de 10 a 15 mg ont ete injectees en 3 jours Les resultats actuels sont bons

En cours de traitement et apres traitement des angiographies de controle ont ete realisees et c est la l autre interet de ces explorations qui permettent d apprecier l effet immediat du traitement et un aspect de son mecanisme d action (Cf Fig 6)

RÉSUMÉ

L angiographie carotidienne elective par voie percutanée (carotide interne et externe) a éte réalisee dans 3 cas d angiofibromes nasopharyngiens apres un examen radiographique et tomographique approfondi du crane et de sa base des sinus et des orbites La contribution essentielle de l angiographie carotidienne est la démonstration d une vascularisation caracte ristique qui permet le diagnostic differentiel avec les autres tumeurs regionales. Bien que benignes ces tumeurs peuvent s accompagner de lesions osseuses importantes notamment de la base du crane et peuvent s étendre a l endocrane L indication et l appreciation de l effica cité d une chimiotherapie anticancéreuse régionale par voie arterielle decoulent quasi automa tiquement des données de l investigation radiologique

SUMMARY

Selective percutaneous carotid angiography (internal and external carotid artery was per formed in 3 cases of nasopharyngeal angiofibroma following roentgen and tomographic exa minations of the sinuses orbits and base of the skull The demonstration of characteristic vascularization permitted the differential diagnosis between other tumours of the regions to be made These benign tumours may produce marked bone changes especially at the base of the skull, and may even extend into the cranium The data obtained will enable the indi ations for and the results of regional intra arterial anticancerous chemotherapy to be assessed.



a b

Fig 6 Cas 3 Angiographie de l'artère carotide externe gauche Profil stade arteriel a) Reperage de l'extremité du catheter avant perfusion d'yperite L'extremite du catheter est située un peu en dessous de l'origine de l'artere maxillaire interne (↔) La tumeur est tres etendue (/) et le réseau angiomateux est tres sérre b) Controle arteriographique apres injection de 10 mg d'yperite Les arteres sont spasmees (↗) leurs parois sont irregulières La vascularisation tumorale est considerablement raréfiee

6° Dans les 3 cas l'angiographie carotidienne a demontre l'extension intracranienne de la lesion Dans les 2 cas de recidive, elle n'a fait que confirmer une presomption retiree des examens directs mais dans le 3eme cas, cette precision doit etre consideree comme un apport supplémentaire aux examens directs puisqu'aucune lesion destructrice de l'étage moyen n'était démontree La confrontation des examens directs et des examens angiographiques permet donc de considerer que les angiofibromes du cavum se comportent comme les *tumeurs malignes en ce qui concerne leur mode d'invasion* de la base du crane Ou bien, ils suivent les orifices preformes fente sphénoidale, trou déchire anterieur, gouttiere carotidienne (MARTIN & BLADY 1940), ou traversent directement les os de la base en les erodant

7° Dans les 3 cas l'artere carotide externe est l'artere nourriciere principale de la tumeur mais chaque fois l'artere carotide interne par l'intermédiaire de l'artere ophtalmique ou de branches vestigiales de la partie intracaverneuse du siphon carotidien vascularise la partie intracranienne de la lesion et meme une partie de sa portion extracranienne Ces faits permettent une nouvelle hypothese pour expliquer la frequence des recidives, meme quand le chirurgien a l'impression d'avoir enleve la totalite de la tumeur la partie de la tumeur qui reste a l'interieur du crane ou dans *les orifices* de la base pourrait regenerer

FROM THE DEPARTMENT OF RADIOLOGY (DIRECTOR K. H. GASKELL), FRENCHAY HOSPITAL, BRISTOL ENGLAND

STENOSIS OF THE CAROTID SIPHON

by

J. L. G. THOMSON

Arteriosclerotic changes are frequently found in the carotid artery and the commonest site has been found to be at or near the origin of the internal carotid artery. Thus HULTQUIST (1941) analysed 3 500 consecutive autopsies and reported arteriosclerotic changes at this site in 2.6 % of cases. NORTHCROFT and MORGAN (1944) examined the carotid artery in 30 consecutive cases of military men who had died from other causes and found a variable degree of atheroma at this site in almost every case. KEIRNS and WHITELEATHER (1959) examined the neck in 626 routine carotid angiograms and they found atheromatous changes in 108 cases. When changes are severe enough to cause marked narrowing of the arterial lumen, surgical reconstruction may relieve the symptoms that arise. EASTCOTT, PICKERING and ROB (1954) were among the first to report such a case and numerous papers have appeared since then.

However, arterial narrowing at other sites in the carotid artery is not so commonly seen or reported but it is recognised that obstructions may occur at the origin of the common carotid artery, higher in the cervical portion of the internal carotid artery, and also in the siphon. BOLDREY and MILLER (1956) reported 5 cases with partial obstruction in the cervical region relieved by surgery. SAPHIR (1935) reported arteriosclerotic changes in the internal carotid artery in its course through the carotid canal and cavernous sinus with occlusion in one case.

Table

Obstructive lesions in cerebral arteries in a total material of 91 cases

	Common carotid artery	Origin of intern carotid artery	Carotid siphon	Mid portion of intern carotid artery	Middle cerebral artery
Partial obstruction	1	19	8	3	3
Complete obstruction	1	34	8	2	12

In Bristol in the last 5 years we have had 8 cases of marked narrowing of the carotid siphon noted at angiography, considered to be the cause of the symptoms This group was recently surveyed among a total of 91 cases of obstructive lesions in the carotid artery, the localisation and degree of which are tabulated in the Table All these cases were followed up in order to ascertain the prognosis of cases with carotid and middle cerebral artery disease and the results have subsequently been reported elsewhere (THOMSON 1961)

It was during this survey that a few points of interest arose, particularly in regard to the 8 cases of partial siphon obstruction, and it was therefore felt worthwhile making a separate report on these cases in view of the absence of any comparable series in the literature

Of the total group 6 were males and 2 were females with an age group from 42 to 63 years In view of some similarity of the clinical history, the following 2 cases only will be summarized

Case reports

Case 1 A male truck driver aged 47 years sought medical advice because of an increasing weakness in his left arm developing slowly over the preceeding four months It was suspected clinically that he had a cerebral tumour and arteriography was therefore carried out

No evidence could be obtained of any space-occupying lesion (subsequently confirmed by air encephalography) but it was noted that the siphon was markedly narrowed and irregular (Fig 1) and that the circulation rate beyond was rather slow It was considered that the defects represented atheromatous deposits and as it was feared that th artery might in time become completely obstructed with resultant hemiplegia anticoagulant therapy was commenced However, haematuria occurred three weeks later and the treatment was therefore terminated

At an enquiry 2 years later it was discovered that the patient had deteriorated a little for the ensuing few weeks after his return home but that he had then slowly improved so that eventually he was able to return to work a year ago and was still thus occupied.

Case 2 A man aged 48 years complained that 3 months ago he had suffered from transient weakness of the left hand lasting for a few minutes Next day he was unable to hold the soap in this hand but recovery later ensued Subsequently a gradually progressive weakness appeared in the left arm and leg Again it was thought clinically that a cerebral tumour might be developing



Fig 1 Case 1 Carotid siphon narrow and irregular



Fig 2 Case 2 Localized thickening of the arterial wall of the siphon (arrows)

At arteriography an elongated indentation was noted in the carotid siphon (Fig 2) with a slow circulation rate beyond The lesion was considered to be an atheromatous plaque and no treatment prescribed At follow up 12 months later the hemiparesis was improving and the patient was contemplating a return to work.

The other case histories were similar to these so that altogether half the cases had a slowly progressive onset of hemiparesis two suffered from recurrent attacks of transient weakness in an arm or leg and the other two had a fairly sudden onset of hemiparesis The clinical presentation is thus very similar to that produced by a partial obstruction elsewhere in the carotid artery In one of the cases a marked bruit was audible in the neck on auscultation with no evidence of any partial obstruction in the cervical part of the artery As a similar bruit was audible in the neck of the patient with partial obstruction at the origin of the common carotid artery (see Table), as well as in several of those with partial obstruction at the origin of the internal carotid artery accurate localisation of the site of the lesion by auscultation is clearly unreliable and arteriography should be carried out in those cases likely to come to surgery

In the follow up of the 8 cases it was interesting to find that 4 cases were well and back at work from 6 months to 2 years after diagnosis Another case had also returned to work but death occurred 2 years later from myocardial infarction The other 3 cases were all still hemiparetic but all of them were

improving at the time of follow up No specific treatment was prescribed in 6 of the cases, the case mentioned (Case 1) having had only a short course, and a further case, a long course of anticoagulants Both these latter two cases had done well

In comparison with the follow up of cases showing partial obstruction elsewhere in the series of 91 patients mentioned, these 8 patients had done well, for of the 19 cases with partial obstruction at the lower end of the internal carotid artery 10 were treated medically, 2 of whom returned to work, and 9 were treated surgically of whom 4 were back at work

It is of some interest therefore to note (1) the differing types of clinical onset in the cases with partial obstruction in the siphon, (2) the occurrence of one case with a cervical bruit on auscultation, and (3) the relatively good prognosis especially in comparison with the more commonly occurring lesions elsewhere

SUMMARY

Eight cases of partial obstruction in the carotid siphon are described with reference to clinical presentation and follow up

ZUSAMMENFASSUNG

Es werden 8 Falle von partiellem Verschluss des Karotissiphon unter Berucksichtigung der klinischen Erscheinungen und Nachuntersuchungsresultate beschrieben

RÉSUMÉ

L auteur presente huit cas d obstruction partielle du siphon carotidien et décrit leurs signes cliniques et leur évolution

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NEURORADIOLOGIC DIAGNOSTIC PROCEDURES IN SUPRASELLAR SPACE OCCUPYING LESIONS WITH SPECIAL REFERENCE TO ANGIOGRAPHIC MEASUREMENTS

by

GEORGE B UDVARHELYI THOMAS W LANGFITT and ARIS COX

It is well known that space occupying lesions in the region of the sella turcica can usually be diagnosed by a careful history neurologic and conventional roentgen examinations of the skull Often surgical removal of tumors in this area may be performed successfully without additional diagnostic procedures However, improvements in carotid angiography and pneumoencephalography have made it possible to make a more complete presurgical evaluation of the nature and extent of suprasellar lesions For example cerebral angiography will in most cases permit the exclusion of the presence of an aneurysm It is rarely possible on the basis of the clinical examination and routine roentgen films of the skull completely to rule out this lesion and the dangers of an unwitting surgical attack on an aneurysm in this location are well known Hence carotid angiography and pneumoencephalography are frequently used where a suprasellar lesion is suspected

Suprasellar space occupying lesions are frequently diagnosed on the basis of displacement of the terminal internal carotid artery its bifurcation and/or the anterior cerebral artery Characteristically these lesions are said to produce one or more of the following vascular alterations lateral displacement of the terminal internal carotid artery and elevation of the first segment of the

anterior cerebral artery in the antero-posterior projection, posterior displacement of the anterior cerebral artery and elevation of the carotid bifurcation in the lateral projection However, surprisingly little information can be found in the literature about the validity of these observations

Since the localization of suprasellar masses on the basis of the above angiographic criteria is often equivocal pneumoencephalography is frequently performed The technique, interpretation and ultimate value of fractional pneumoencephalography in the diagnosis of these lesions has been extensively studied during the past decade The pneumoencephalogram is of particular value in determining the limits of the mass by displacement of the basal cisterns and the anterior third ventricle However, in a significant number of cases with suprasellar masses either one or both of these diagnostic procedures have been interpreted as normal, or, at least failed to permit a definitive diagnosis

The present investigation intends to provide the following information

1 Normal variations in the position and configuration of the terminal carotid artery and the anterior cerebral artery based on the measurement of several arbitrarily selected angles and distances, and differences between the normal angiograms and angiograms in those cases in which a suprasellar mass was confirmed by surgery or autopsy

2 An analysis of the cerebral angiograms and pneumoencephalograms including those which were interpreted as normal, in cases subsequently proven to have suprasellar masses at the time of surgery or autopsy

Materials and Methods Initially, antero posterior and lateral cerebral angiograms of seventy five cases were analyzed These angiograms were interpreted as being normal and subsequent follow up has failed to demonstrate any neurosurgical lesion It is of course possible that in one or more of these cases an asymptomatic suprasellar mass may have been present but this is considered to be quite unlikely All of these studies were performed in adults, regardless of age or general condition However only those angiograms have been analyzed which are technically comparable Thus insofar as possible true lateral projections and antero posterior projections at an angle of 25 to 30 degrees to the vertical radiological line were used

The following arbitrary angles and distances have been measured as a standard for comparison with the angiograms obtained in cases of proven suprasellar lesion

A Antero posterior projection (Fig 1)

1 Angle alpha, the angle between the midsagittal line and a line drawn tangentially through the intracranial portion of the internal carotid artery

2 Angle beta, the angle between a horizontal line drawn from the bifurcation of the internal carotid artery perpendicular to the midsagittal line

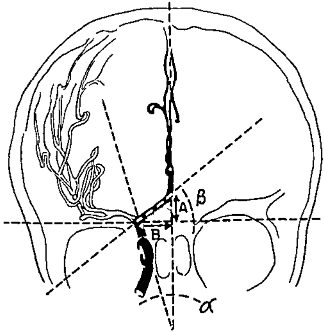


Fig 1 Drawing of the antero posterior projection of an angiogram indicating angle alpha and distance B for the internal carotid artery and bifurcation point and angle beta and distance A for the anterior cerebral artery

and a line from the bifurcation of the internal carotid artery through the most convex portion of the first part of the anterior cerebral artery

3 Distance A the distance between the junction of the anterior cerebral and anterior communicating arteries and the intercept of a line drawn from the bifurcation of the internal carotid artery perpendicular to the midsagittal line

4 Distance B, the distance from the bifurcation of the internal carotid artery to the midsagittal line

B Lateral projection (Fig 2)

1 Angle gamma, the angle formed by a line between the internal occipital protuberance and the nasion and a line from the bifurcation of the internal carotid artery through the most concave portion of the anterior part of the pericallosal artery

2 Distance C the perpendicular distance from the occipital nasion line to the bifurcation of the internal carotid artery

3 Distance D the distance from the bifurcation of the internal carotid

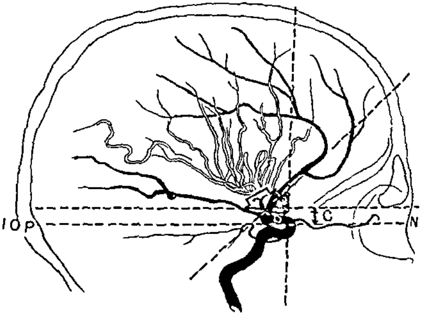


Fig 2 Drawing of the lateral projection of an angiogram indicating distances C and D for the bifurcation point and angle gamma for the anterior cerebral artery

artery to a point one third the distance from the nasion to the internal occipital protuberance

4 Distance A plus C is the sum of distance A in the antero posterior projection and distance C in the lateral projection and provides information on the position of the anterior cerebral anterior communicating junction in relation to the horizontal base line

This part of the study includes also the evaluation of 38 cerebral angiograms, of comparable technique to the normal, in cases subsequently demonstrated to have suprasellar lesions, as enumerated below

Pituitary adenoma	23
Craniopharyngioma	8
Suprasellar meningioma	7
Chordoma	1

Because of the relatively small number of cases, no attempt has been made to analyse the angiograms with reference to the specific type of tumor present

This information from the cerebral angiograms in both the patients and those with suprasellar lesions has been plotted on a co ordinate system in which the abscissa represents values for an angle or a distance and the ordinate represents the frequency of occurrence of these values The resultant curves from the normal and pathologic angiograms, are superimposed for each angle

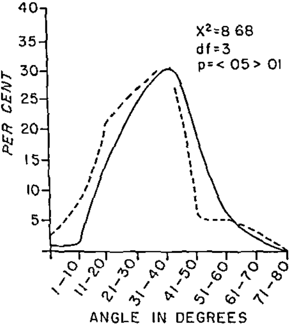


Fig 3 Diagram of the variations of angle alpha in normal and pathologic cases The two curves are well superimposed No significant difference statistically
——— Normal cases (95)
— — — Pathologic cases (39)

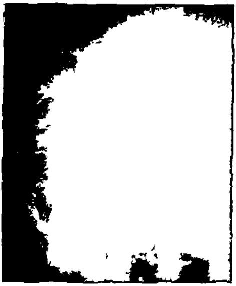
and distance The chi square test has been used to compare the two curves for each angle and distance

The second part of this investigation is a comparison of the relative efficacy of cerebral angiography and pneumoencephalography in the diagnosis of suprasellar masses

A total of 229 cases were reviewed for this report Initially 119 cases were excluded primarily because neither a cerebral angiogram nor a pneumoencephalogram had been performed prior to surgery Many of the pituitary adenomas and several craniopharyngiomas were surgically explored on the basis of clinical findings and alterations in the conventional films of the skull The remaining 110 cases were grouped as shown below

	Number of cases studied	Number of cases used
Pituitary adenoma	37	23
Aneurysm of internal carotid	37	none
Craniopharyngioma	10	8
Suprasellar meningioma	11	7
Sphenoidal ridge (internal 1/3) meningioma	8	none
miscellaneous	7	1
Total	110	39

Cases of internal carotid artery aneurysms or meningiomas of the inner one third of the sphenoid ridge were excluded as not being pertinent to this





a b

Fig 4 Antero posterior (a) and lateral (b) views of an angiogram in a normal case Angle alpha = 50 angle beta = 40 distance A = 7 mm distance B 20 mm (values falling into the range of pathologic cases) Angle gamma = 34 distance C = 18 mm distance D 13 mm (normal values)

study Of the remaining 65 cases, 15 pituitary adenomas 2 craniopharyngiomas, 4 suprasellar meningiomas and 6 miscellaneous tumors were excluded because the positioning of the patient or the technical quality of the angiograms did not meet the criteria for measurement

The pneumoencephalograms were evaluated according to the criteria of other investigators (SCHLESINGER, RUGGIERO, BAKAY, DECKER, BELLONI LENZI and others)

Comparison of angles and distances in normal and pathologic cases

A Antero posterior projection

1 Angle alpha the angle between the midsagittal line and a line drawn tangentially through the intracranial portion of the internal carotid artery, showed marked variation in both the normal and pathologic cases In the normal, the mean value was 34 with a standard deviation of ± 11 7° In about 5 % of cases the angle varied between 50 and 70 The values for the pathologic cases showed a mean of 30° and a standard deviation of ± 12 6 The distribution curves (Fig 3) are quite similar There is a suggestion that the angle in the pathologic cases is actually less than in the normal cases which of course, one would not expect with a suprasellar mass In fact the difference between the two curves is of doubtful statistical validity (Fig 4a)

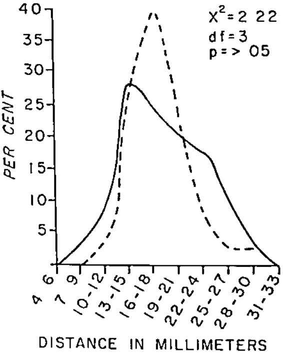


Fig 5 Diagram of the variation of distance B in normal and pathologic cases. No significant difference can be noted
——————— Normal cases (95)
— — — — Pathologic cases (39)

2 Distance B the distance from the bifurcation of the internal carotid artery to the midsagittal line also varied considerably in both groups Values from 5 to 32 mm with a mean value of 17 4 mm and a standard deviation of ± 4 4 mm were found in the normal group A comparison with the pathologic cases (Fig 5) shows a somewhat steeper pathologic curve but the difference is not statistically significant Indeed many of the cases showing maximal displacement of the carotid bifurcation were among the normal group (Fig 6)

3 Angle beta, the angulation of the proximal anterior cerebral artery with respect to the horizontal plane, was found to be between — 10 and + 10 in 68 % of the normal group In the pathologic cases (Fig 7) there was a statistically significant shift toward greater angulation with a mean value of 25 and a standard deviation of ± 24 Only 15 % of the pathologic case showed an angulation of 10 or less compared to 68 % in the normal group However angles between 30 and 70 were found in 5 to 10 % of the normal cases indicating the difficulty in interpretation within a given study

4 Distance A the distance from the horizontal plane at the bifurcation of the internal carotid artery to the junction of the anterior cerebral and anterior communicating arteries also showed considerable variation but as

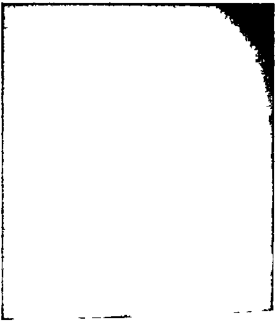


Fig 6 Antero posterior view of an angiogram in a normal case
Angle alpha = 32 angle beta = 22 distance A = 10 mm distance B = 23 mm

demonstrated in Fig 8 there was a statistically significant difference between the normal and pathologic groups Again, the observation that within the normal group values were found of up to 6 mm in 12 % and up to 10 mm in 5 % of the angiograms studied, indicates that a marked elevation of the anterior cerebral artery may occur as a normal variant The mean values in the normal and pathologic groups were 0 5 mm and 5 4 mm, and the standard deviations were $\pm$ 6 9 mm and $\pm$ 7 5 mm respectively

B Lateral projection

1 Angle gamma, the angle between the occipital nasion line and a line through the most concave part of the pericallosal artery was difficult to measure in many studies and ranged from 10 to 80° in the normal group In the normal and pathologic groups the mean values were 41° and 44 7 , respectively, and the standard deviation $\pm$ 15 and $\pm$ 12 3 , respectively The difference between the two groups was not statistically significant (Fig 9)

2 Distance C, the perpendicular distance from the occipital nasion line to the bifurcation of the internal carotid artery, varied between 10 and 30 mm in the normal and pathologic groups The mean values were 20 1 mm and 20 2 mm respectively, with a standard deviation of $\pm$ 4 7 mm and $\pm$ 6 mm respectively There was no statistically significant difference between the two groups (Fig 10)

3 Distance D, which is a measure of the position of the bifurcation of the internal carotid artery in the antero posterior direction showed extremely

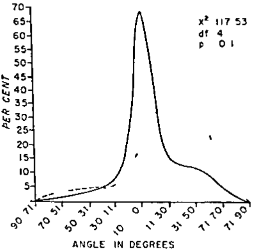


Fig 7 Diagram of the variations of angle beta in normal and pathologic cases Significant shift to the right in the pathologic group Sixty-eight per cent of the normal cases fell within — 10 and + 10

— Normal cases (85)
--- Pathologic cases (39)

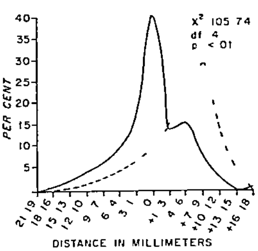


Fig 8 Diagram of the variation of distance \ in normal and pathologic cases Statistically significant difference can be noted as seen from the shift to the right in the pathologic group

— Normal cases (95)
--- Pathologic cases (39)

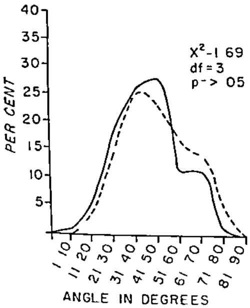
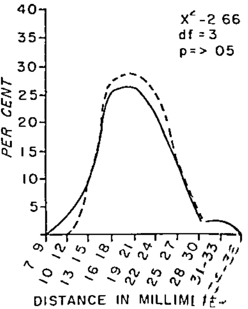


Fig 9 Diagram of the variation of a ɑl mma in normal and pathologic cases \ g ficant diff rence the two curves ar sup n ıp ed

— Normal ca es (95)
--- Patholog c cases (36)



F 10 Diagram of the a iati in in normal and pathologic c d fferen

— Norm l cases (84
--- P tholog c cases 36)

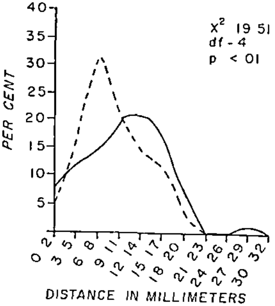


Fig 11 Diagram of the variations of distance D in normal and pathologic cases There is a shift to the left in the latter group showing values of between 8 and 11 mm in more than 30 of the cases studied
— Normal cases (84)
— Pathologic cases (36)

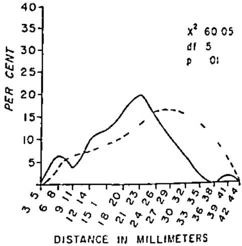


Fig 12 Diagram of the variations of distance A + C in normal and pathologic cases Sli ht shift to the right in the latter group can be seen
— Normal cases (85)
Pathologic cases (38)



Fig 13 Lateral angiogram in a normal case Angle gamma = 40 distance C = 25 mm distance D = 19 mm

wide variation in both groups However, the comparison between the two groups (Fig 11) is of particular interest because the carotid bifurcation would appear to be displaced anteriorly in the pathologic group and this difference

is statistically significant Usually one expects posterior displacement of the carotid bifurcation in the presence of a suprasellar mass, but not in a normal study (Fig 13) In the normal and pathologic groups the mean values were 10 5 mm and 8 8 mm respectively, with a standard deviation of ± 6 1 mm and ± 3 9 mm respectively

4 Distance A plus C, which is an expression of the possible elevation of both the internal carotid artery bifurcation and the anterior cerebral artery, shows a statistically significant difference between the two groups (Fig 12) Since the significance of this difference does not appear to be any greater than that demonstrated with distance A alone addition of the two distances is of no particular value

Statistically significant differences were found only in one angle (beta) and in two distances (A and D)

Analysis of angiograms and pneumoencephalograms in cases of proven suprasellar space-occupying lesions

We have accepted as a positive diagnostic study (+) the angiograms in which at least angle beta and distance A were within the values more frequently observed in pathologic cases We have called the angiographic study doubtful (±) when only one of these criteria showed pathologic changes, and the angiogram was graded as negative (—) when there was no significant change present

Similarly, the pneumoencephalographic studies were graded as positive (+) doubtful (±) or negative (—), according to their diagnostic significance The well established criteria of displacement and obstruction of the basal cisterns

Table 1

	Angiography	Air study	Surgery	False negative
Craniopharyngiomas				
1 — 611883	+	+	+	
2 — 712434	+	+	+	
3 — 647025	+	±	+	
4 — 119737	—	±	+	×
5 — 499145	±	±	+	×
6 — 614236	+	+	+	
7 — 800165	—	—	—	
8 — 733676	—	none	+	×
Suprasellar meningiomas				
1 — 78953	—	—	+	
2 — 159745	—	+	+	
3 — 832273	∓	+	+	
4 — 533333		±	+	×
5 — 985431		+	+	
6 — 616075		+	+	
7 — 652751	—	±	+	×

and displacement of the anterior third ventricle were used, as outlined by SCHLEZINGER, ROBERTSON, LINDGREN, BAKAY and WHITE, KAUTZKY and ZULCH, RUGGIERO, DECKER

The groups of craniopharyngiomas and suprasellar meningiomas are presented in Table 1 Out of the 8 craniopharyngiomas, both diagnostic studies were positive in three, the angiograms were negative in three, but the pneumoencephalogram was definitely positive in one, doubtful in one, and not performed in the third From the remaining cases in this group, the angiogram was positive in one, but the pneumoencephalogram was doubtful, and in the other, both studies were doubtful

From the 7 suprasellar meningiomas, both studies were positive in two cases, the angiogram was doubtful or negative in three cases, but the pneumoencephalogram was highly diagnostic Both studies were of doubtful value in one case, and in the other the angiogram was negative and the air study doubtful

An analysis of the 23 pituitary adenomas is given in Table 2 In only nine cases were both diagnostic studies performed Out of the nine, both studies were positive in three, the angiogram was negative in three but the pneumoencephalogram was positive, and in the remaining three the angiogram was doubtful and the air study positive in one, doubtful in the other, and was

Table 2

Pituitary adenomas

	Angiography	Air study	Surgery	False negative
1 — 420861	±	±	+	
2 — 661939	+	+	+	
3 — 135434	±	+	+	
4 — 769124	+	+	+	
5 — 821499	+	none	+	
6 — 876920	—	none	+	×
7 — 821504	+	none	+	
8 — 830476	+	none	+	
9 — 794008	±	+	+	
10 — 661863	±	none	+	×
11 — 785123	none	+	+	
12 — 877376	±	none	+	×
13 — 329820	±	none	+	×
14 — 878094	—	none	+	
15 — 640558	—	+	+	
16 — 779784	+	none	+	×
17 — 868813	—	none	+	×
18 — 823450	±	none	+	
19 — 564575	—	+		×
20 — 683610	±	none	+	
21 — 605732	—	+		
22 — 131731	±	none		
23 — 844684	—	+	+	

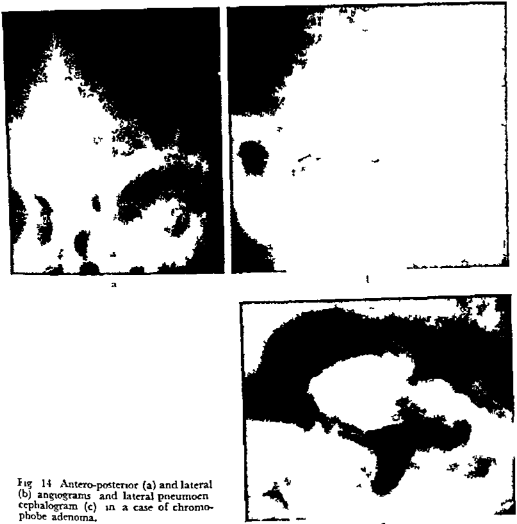


Fig 14 Antero-posterior (a) and lateral (b) angiograms and lateral pneumoencephalogram (c) in a case of chromophobe adenoma.

not performed in the third. In 13 cases angiography alone and in one case pneumoencephalography alone, were performed. Of the 13 cases with angiography, four angiograms were positive, six angiograms were doubtful and three angiograms were negative.

Of the 10 cases with pneumoencephalograms nine were positive and only one doubtful.

In all three groups we designated as false negative those in which one study was negative and the other one doubtful or in which only one diagnostic study was performed and this was of negative or doubtful value. Three of the 8 craniopharyngiomas, two of the 7 suprasellar meningiomas and nine of the 23 pituitary adenomas fall into this category.

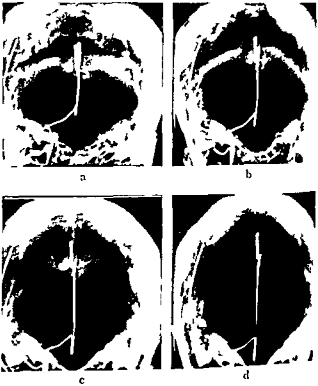


Fig 15 Antero posterior views of a skull in which the course of the internal carotid artery and of the anterior and middle cerebral arteries have been outlined with copper wire The proximal anterior cerebral artery runs in the coronal plane Tube angulation caudally a) 20 b) 25 c) 30 and d) 35 There is no difference in angle beta (30) in the four projections

Discussion

An analysis of these measurements in the normal angiograms confirms the previous impression of many investigators that there is marked variation in the normal course of the internal carotid artery intracranially There has been comment on this in most of the comprehensive works about cerebral angiography (MONIZ, FISCHER BRUGGE, LIMA, ECKER, KRAYENBUHL and RICHTER BONNAL and LEGRE, TONNIS and SCHIEFER DECKER, WICKBOM) However, little attempt has been made objectively to assess these variations CURRY and CULBERT, analysing 50 normal angiograms, comment on the false interpretations of the angulation of the internal carotid artery, and call attention to the difficulty in differentiating a pathologic change from a normal configuration Variations at the level of the siphon have been studied by TARTARINI and GIUGNI, PIMENTA and MANGABEIRA ALBERNAZ, SCHIEFER and VETTER in normal and pathologic angiograms In many reports there is reference to opening or elevation of the distal siphon as a normal variant as well as in pathologic conditions Usually, the position of the bifurcation is mentioned in conjunction with variations of the siphon In the present studies, angle alpha and distance B in the antero posterior projection and distances C and D, in the lateral projection, were made in order to assess variations in the angulation of the terminal internal carotid artery and the

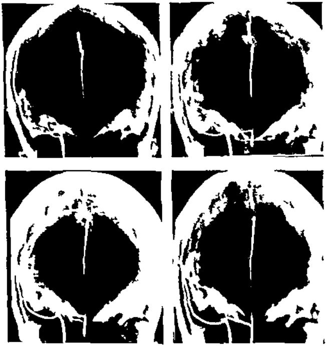
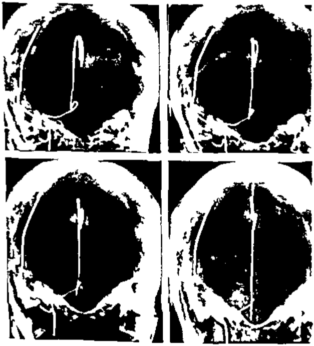


Fig 16 The wire representing the proximal anterior cerebral artery runs about 15 to 20 anteriorly The same tube angulations (20 2› 30 and 35) show changes of angle beta from 0 to —8



F g 17 The wire represent ng the proximal anterio c ebral artery runs about 15 to 20 posteriorly The same tub angulations show hanges of angle beta up to 10

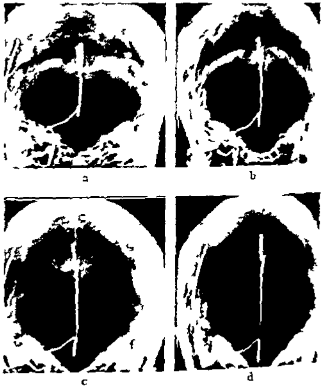


Fig 15 Antero-posterior views of a skull in which the course of the internal carotid artery and of the anterior and middle cerebral arteries have been outlined with copper wire The proximal anterior cerebral artery runs in the coronal plane Tube angulation caudally a) 20 b) 25 c) 30 and d) 35 There is no difference in angle beta (30) in the four projections

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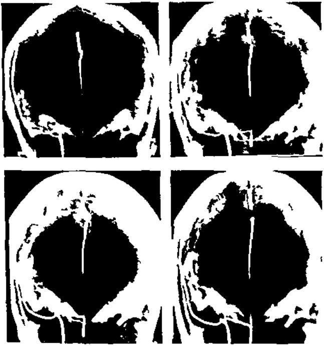


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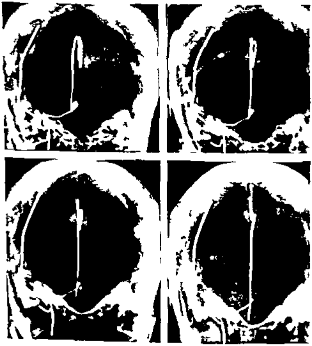


Fig 17 The wire representing the proximal anterior cerebral artery runs about 15 to 20 posteriorly The same tube angulations show changes of angle beta up to 10

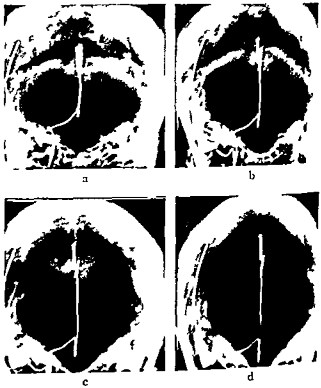


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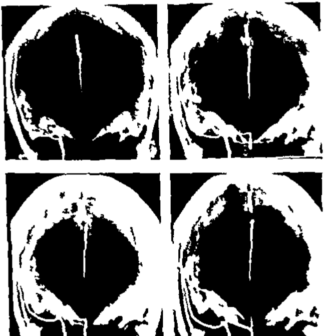


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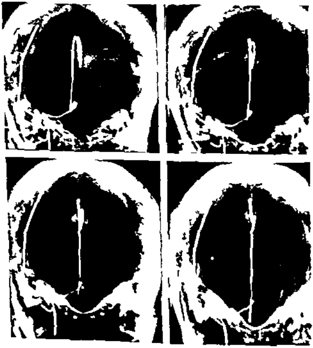


Fig 17 The wire representing the proximal anterior cerebral artery runs about 15 to 20 posteriorly The same tube angulations show changes of angle beta up to 10°

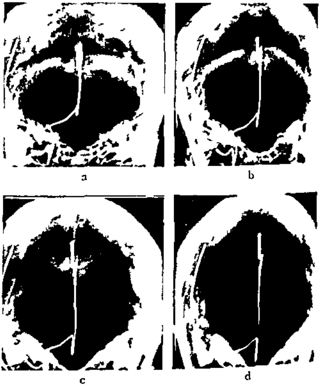


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a b

Fig 18 A.p angiogram (a) and lateral pneumoencephalogram (b) in a case of chromophobe adenoma. A subjective interpretation of the arteriogram suggested elevation of the terminal carotid artery and the anterior cerebral artery but the extens on of the lesion is quite well demonstrated in the encephalogram. Measurements angle alpha 18 angle beta 34 angle gamma 65 distances A = 9 mm, B = 20 mm, C = 25 mm, D = 2 mm, A + C = 34 mm. Both studies were of diagnostic value

interpretation by failure to consider the effect of the roentgen tube angulation on the configuration of the involved vessel As emphasized by GERLACH and VIEHWEGER, TONNIS and SCHIEFER, BONNAL MORRIS and PECK apparent pathologic displacement of the carotid bifurcation may be due to technique

In a simple model using copper wires in a skull we could demonstrate that tube angulations, to the vertical radiological line between 20—25—30 and 35 degrees did not modify angle beta when the wire representing the anterior cerebral artery was running exactly in the coronal plane (Fig 15) However if the anterior cerebral artery runs in an angle of 20 forward or in an angle of 20 backward, modifications of up to between 5 and 10 degrees

Table 3 (cont)

Both					
—	±	∓	± ∓	± —	— —
0/9	1/9	3/9	2/9	0/9	3 9
(0)	(11 %)	(33 %)	(22 %)	0)	(33 %)
0/7	1/7	3/7	1 7	1 7	1/7
(0)	(14 %)	(43)	(14	14)	(14 %)
0/7	1/7	2/7	2 7	1/7	1/7
(0 %)	(14)	(28 %)	?8	14 %)	(14 %)
0/1	0/1	0/1	1 1	0/1	0/1
0/24	3/24	8/24	6 ?4	2/24	5/24
(0)	(12 %)	(33)	25	(8 %)	(20 %)



a b



c

Fig. 19. A.p. (a) and lateral (b) projections of the angiogram and lateral pneumoencephalogram (c) in a case of suprasellar meningioma. The cerebral angiograms strongly suggested a suprasellar lesion but did not provide as much information as the pneumoencephalogram in which the position and extension of the tumor is clearly demonstrated. Measurements: angle alpha 76, angle beta 38, angle gamma 34; distances A = 11 mm, B = 24 mm, C = 25 mm, D = 15 mm and A + C = 36 mm. The outline of the tumor can be well appreciated in the air study. Both studies are of diagnostic value.

could be observed in the higher (30—35—40 degrees) tube angulations (Figs. 16 and 17).

Angle beta and distance A in the a.p. projection and angle gamma in the lateral projection are a measure of the course of the inferior part of the pericallosal artery and its junction with the anterior cerebral and communicating arteries. Extensive studies have evaluated the variations in the anatomy of the anterior cerebral and pericallosal arteries (CRITCHLEY, BEEVOR, FAWZETT and BLACHFORD, HASENJÄGER, KLEISS, LAZORTHES et coll., MITTERWALLNER, MOREL and WILDI, GOVAERT) and its appearance and dynamic function in cerebral angiography (CURRY and CULBRETH, FISCHER, ETHELBURG, DECKER, GUND, LIMA, MANGHI et coll., MORRIS and PECK, OEKROS, RUGGIERO, WORINGER and GERNEZ, ZEHNDER). The hemodynamic significance of the anterior portion of the circle of Willis has been exhaustively considered mainly in relation to aneurysms of these vessels (KRAYENBUHL et coll., NORLÉN

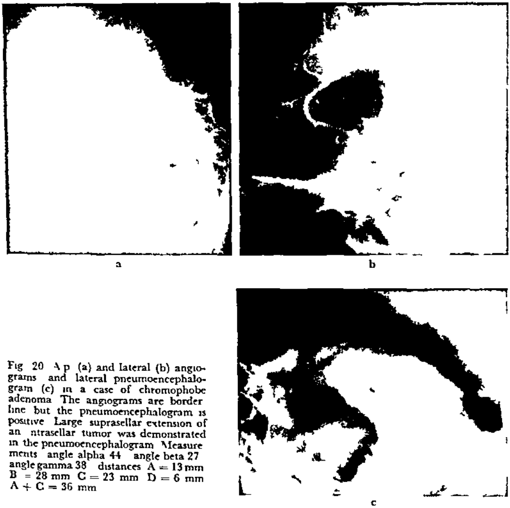


Fig 20 A p (a) and lateral (b) angiograms and lateral pneumoencephalogram (c) in a case of chromophobe adenoma The angiograms are border line but the pneumoencephalogram is positive Large suprasellar extension of an intrasellar tumor was demonstrated in the pneumoencephalogram Measurements angle alpha 44 angle beta 27 angle gamma 38 distances A = 13 mm B = 28 mm C = 23 mm D = 6 mm A + C = 36 mm

and BARNUM GILLINGHAM ASK UPMARK, SCHURMANN SNELLMAN et coll LEPOIRE and COXAM) However, most statements concerning the course of the pericallosal artery in cerebral angiograms are quite general and MORRIS and PECK following the study of 100 cases, in the lateral projection only, caution against the diagnosis of suprasellar lesions on the basis of the angiogram alone They urge the use of both angiographic and pneumoencephalographic studies in cases of suspected lesions CURRY and CULBRETH have commented on the size and diameter of the pericallosal artery in 50 cases studied They mention the frequent tortuosity of the vessel in a p projections and give measurements of its length LIMA calls attention to the importance of a p and half axial projections in studying variations of the anterior cerebral and pericallosal arteries The significance of an elevation of the first portion of



a



b

Fig 21 A.p (a) and lateral (b) angiograms in a case of craniopharyngioma. Measurements angle alpha 46 angle beta 28 angle gamma 41 distances A = 4 mm B = 17 mm, C = 25 mm, D = 6 mm A + C = 29 mm

the artery in a p projection, in suspected suprasellar lesions, has been extensively quoted (MONIZ, KRAYENBUHL and RICHTER FISCHER BRUGGE, WICKBOM and SHELDON, BONNAL, DECKER, KAUTZKY and ZÜLCH, LIMA) The present findings support these observations as indicated by the fact that angle beta was found to be within plus or minus 10 in nearly 70 % of the normal cases studied, with an increase in the angle in only 12 % of the normal ones As previously noted Figs 7 and 8, substantial displacement of the anterior cerebral artery occurred in most of the pathologic cases On the other hand, angle gamma, in the lateral projection did not show a significant difference between the two groups, supporting the impression of MORRIS and PECK

In spite of the fact that the measurements of distance A and angle beta showed statistically significant differences between normal and pathologic cases in this series the application of these measurements in practice has only limited value In only 4 of 8 craniopharyngiomas 2 of 7 suprasellar meningiomas, and 7 of 22 pituitary adenomas, were the measurements of definite diagnostic value Of the remainder, 3 of the craniopharyngiomas 2 of the suprasellar meningiomas and 9 of the pituitary adenomas would have been interpreted as false negatives

Numerous authors (WICKBOM, RUGGIERO, DECKER LINDGREN SCHLESINGER DYKE and DAVIDOFF SCHULLER, BAKAY and WHITE, HANELIN and BAKAY, ROBERTSON) have stated that more reliable information can be obtained from

a pneumoencephalogram in the diagnosis of suprasellar lesions In the present study, 76 % of cases (19 of 25) with suprasellar lesions had a positive pneumo encephalogram, which is approximately the same value as that quoted by RUGGIERO (26 of 34 extracerebral suprasellar lesions, 76 4 %) In comparison, our angiographic criteria led to a positive diagnosis in only 13 out of 38 cases (34 %) (See Table 3)

In comparing the two diagnostic procedures with respect to the specific lesions found angiography was of diagnostic assistance in 50 % of the cranio pharyngiomas, 33 % of the pituitary adenomas and 28 % of the suprasellar meningiomas In contrast pneumoencephalography was of diagnostic assist ance in 57 % of the craniopharyngiomas, 90 % of the pituitary adenomas and 71 % of the suprasellar meningiomas Finally, if those cases are grouped together which have had one negative diagnostic study and the other of doubtful value or which have had only one study and this was of negative or doubtful value, the percentage of false negative studies is as follows pituitary adenomas 40 %, craniopharyngiomas 37 5 % suprasellar meningiomas, 28 5 %

It should be well recognized that measurements of angles and distances in radiology must perforce be subjective The delineation of the exact point at which a radiolucency ends and a density begins is in many instances, a difficult task Therefore for a given measurement in radiology to be useful reference points on the roentgenogram must be relatively easily identified Moreover the identification of these reference points should be within the capabilities of the general radiologist as well as the experienced neuroradiologist

As a rough test of whether or not the angiographic measurements described in this paper could be reproduced by others we enlisted the aid of ten assistant residents in radiology at the Johns Hopkins Hospital

These trainees in radiology independently measured angle beta and distance A in twenty sets of angiograms They had no knowledge of whether the films were of normal or abnormal subjects

In 200 measurements of angle beta, 79 % were within 5 degrees of the determinations made by the authors In 200 measurements of distance A 87 % were within 2 mm of the observations made by the authors

As might have been anticipated there was no absolute agreement among various observers, a situation illustrating that any arbitrary figures applied to these vascular configurations must be accepted with caution

Acknowledgements

We wish to express our gratitude to Professor A Earl Walker Head of the Division of Neurosurgery and Professor Russell H Morgan Head of the Department of Radiology for their help and encouragement during this study Dr Murray Mitts resident in Neurosurgery gave us valuable help in the statistical anal sis

SUMMARY

A method of utilizing arbitrary lines and angles is described whereby the location of the terminal internal carotid artery and the anterior cerebral artery can be ascertained and their relation to each other estimated Comparing the angiograms obtained it was found that many normal individuals showed vascular configurations more bizarre than those of verified tumor patients and in many patients with tumors the vessels appeared normal in every respect Only two characteristic changes in the vascular configuration about the sella were found to be clinically useful Cerebral arteriography and encephalography are compared with respect to the accuracy in detecting suprasellar tumors

ZUSAMMENFASSUNG

Ein planmassiges System von Hilfslinien und Winkeln wurde angewendet um den Endabschnitt der Arteria carotis interna und die Arteria cerebralis anterior aufzufinden und um deren relative Beziehungen zu bestimmen Es wurde gefunden dass unter normalen Bedingungen ofter mehr bizarre Verhaltnisse vorzufinden sind als in verifizierten Fallen von Gehirntumor in denen oft normale Gefassverhaltnisse zu finden sind Nur zwei typische abnormale Gefässbilder wurden in der Sellagegend festgestellt Ein Vergleich wird gezogen zwischen der Verlasslichkeit der Arteriographie und der Enzephalographie in Fallen von suprasellaren Tumoren

RÉSUMÉ

Les auteurs décrivent une méthode d utilisation de lignes et d angles arbitraires permettant de déterminer la localisation de la partie terminale de l artère carotide interne et de l artère cérébrale antérieure et d estimer leurs rapports réciproques La comparaison des angiographies montre que de nombreux individus normaux ont une configuration vasculaire plus bizarre que celle de sujets atteints de tumeur suprasellaire vérifiée et chez de nombreux sujets atteints de tumeur les vaisseaux étaient normaux à tout points de vue Les auteurs n ont trouvé que deux modifications caractéristiques de la configuration vasculaire dans la région sellaire présentant une constance suffisante pour être utiles cliniquement Les auteurs comparent l artériographie cérébrale et l encéphalographie pour la précision du diagnostic des tumeurs suprasellaire

Addendum in the proofs

Since the submission of this paper for publication the various angiographic measurements have been applied in many cases At the suggestion of WALKER the following formula may be used to indicate a normal or pathologic configuration of the carotid anterior-cerebral artery complex $\Delta = 2A\beta - 100$

β being the angle β in degrees (if negative it is considered zero)

A being the distance A in mm (if negative it is considered zero)

Δ if negative indicates that the chances are better than 81 in 100 that the configuration is normal if positive indicates that the chances are better than 90 in 100 that the configuration results from a pathologic lesion

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KINKING OF THE INTERNAL CAROTID ARTERY OVER THE OPTIC NERVE AND CHIASM IN ACUTE INTRACRANIAL MASS LESIONS

by

KEASLEY WELCH and THOMAS K. CRAIGMILE

During the acute and severe displacement of intracranial structures which accompanies rapidly expanding lesions on one side of the brain there occasionally occurs angulation of the internal carotid artery over the optic nerve or chiasm with kinking of the vessel at this site The resulting impingement upon the lumen of the artery may be revealed by angiography as a local notch

This brief report is designed to call attention to this occurrence and to describe and illustrate the angiographic changes and the mechanisms responsible for them

Angiographic features In the frontal projection, the internal carotid artery after passing beyond the anterior clinoid process has a straight course for a short distance Its axis then becomes abruptly altered as the vessel is displaced medially The fulcrum about which the axis is thus rotated is not the attachment of the vessel where it pierces the dura but it is a point above this and at this point of angulation there is an indentation in the medial aspect of the artery In the more severe cases the artery has been inclined medially more than 30 degrees from the perpendicular above the point of angulation



Fig 1 Diagram demonstrating the normal anatomical relationship of the internal carotid artery with the optic nerve and chiasm

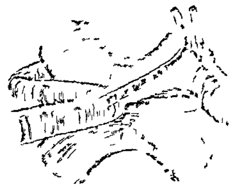


Fig 2 Diagrammatic illustration of distortion and compression of internal carotid artery along with displacement of middle and anterior cerebral arteries which may occur in acute space occupying intracranial lesions

In the lateral projection, the indentation in severe kinking is seen as an hour glass deformity In less severe situations, there may be only a linear defect at right angles to the long axis of the vessel (Figs 1 and 2)

Case material In 8 cases of lesions causing severe displacement of the hemisphere this deformity was demonstrated In all except one, a traumatic hematoma was responsible and in only one of the latter was the process not acute In one instance an intracerebral and subdural abscess was present (Fig 3)

In one case of a rapidly developing hematoma occlusion progressed to completion during the radiographic examination, and at autopsy the kinking of the artery was observed

Expanding lesions of sufficient magnitude to produce this change at angiography result in a similarly great compressive effect on the mid brain This is exemplified in our cases by the fact that each patient was deeply comatose and that out of 8 patients but three survived

Discussion

When an expanding lesion occurs in one hemicranium there are two routes of escape for the tissue of that hemisphere through the tentorial hiatus and beneath the falx into the other hemicranium Although some lateral distortion of the optic nerves and chiasm may undoubtedly take place, the attachments through the optic tracts to the diencephalon and brain stem insure that their principal displacement be downward The tethering of the internal carotid artery is a double one through the posterior communicating artery to structures where principal movement is downward and through the anterior cerebral artery to the laterally shifting cerebral hemispheres the latter predominating because of the greater extent of shift in this direction (In the most



Fig 3 Case of acute subdural and intracerebral abscess a) Lateral arteriogram An hour glass deformity of the internal carotid artery is seen at the level of the anterior clinoid b) Antero-posterior arteriogram The deformity of the carotid artery is visible as a notch on its medial aspect (arrow)

severe of our cases, the bifurcation of the internal carotid artery was shifted to the midline) This combination of circumstances changes the relations of the optic nerve and chiasm on the one hand and the internal carotid artery on the other so that instead of lying more or less side by side the artery crosses the lateral border of the nerve or chiasm and is angulated at the line of intersection

Kinking implies the application of leverage and just as a small child is able to kink a garden hose and obstruct flow against a force which could not be overcome directly so the forces involved in the displacement of the brain need not approach arterial pressure in order that serious impingement upon the lumen take place Such impingement which may progress to complete obstruction can compound the already serious injury to the hemisphere and midbrain

The changes which are described resemble at least in the lateral projection of the angiogram those seen with spasm of the internal carotid artery and are best distinguished from this in the frontal projection

SUMMARY

Angulation of the internal carotid artery over the optic nerve or chiasm was observed in 8 cases with acute intracranial mass lesions This impingement upon the lumen of the artery was demonstrated in the antero posterior projection as a local notch while in the lateral views it was seen as an hour glass deformity or a linear defect A traumatic hematoma was responsible for the defect in seven cases an acute subdural and intracerebral abscess being present in the other

ZUSAMMENFASSUNG

Abknickung der Arteria carotis interna uber dem Nervus opticus und dem Chiasma wurde in 8 Fallen von akuten Massenansammlungen im Schadel gefunden Die Verwolbung in das Lumen der Arterie erschien auf der a p Schadelaufnahme als eine Kerbe auf der Seiten aufnahme erschien sie sanduhrformig oder als eine dunne Linie Ein traumatisches Hamatom war die Ursache in 7 Fallen akuter subduraler oder intracerebraler Abszess verursachte die Erscheinung im achten Fall

RÉSUMÉ

Les auteurs ont observé une angulation de l artere carotide interne sur le nerf optique ou le chiasma dans 8 cas de lesion expansive intracranienne aigue Cette compression de la lumiere de l artere a ete mise en evidence en incidence antero-postérieure sous l aspect d une encoche localisée alors que sur les radiographies de profil elle se présente comme une déformation en sablier ou un defaut d opacification linéaire La cause de cette encoche était dans sept cas un hématome traumatique et un abces sous-dural et intracérébral aigu dans le huitième cas

FROM THE ROENTGEN DEPARTMENT (DIRECTOR PROF ERIK LINDGREN), SERAFIMERLASARETTET, STOCKHOLM, SWEDEN

ANGIOGRAPHIC CHANGES IN NEURINOMA OF THE TRIGEMINAL NERVE

by

GUNNAR WESTBERG

Neurinomas of the trigeminal nerve grow in the gasserian ganglion or trigeminal nerve root The main bulk of the tumor may be located in Meckel s cavity or in the pontine angle region, depending on its origin, although the tumor usually lies in both locations and is therefore shaped like an hour glass When the tumor grows in the former situation it is pressed against the base of the skull by the overlying unyielding dura and owing to this pressure skeletal changes arise at an early stage a sharp edged clearly delimited bone defect at the apex of the pyramid and in the floor of the middle fossa

The changes were described in detail by LINDGREN (1941) who demonstrated that areas of destruction in the tip of the pyramid were a sign that the tumor was also involving the posterior fossa A conventional roentgen examination of the skull is thus the best method of diagnosis but provides only an approximate idea of the size of the tumor which, however may be determined by encephalography with examination of the cisterns These changes are now well known whereas the vascular changes produced by the tumor do not seem to have been studied in detail

The normal anatomy of the trigeminal region is shown in Fig 1 The trigeminal nerve root lies infratentorially in the pontine angle The ganglion is located supratentorially in a dural sac immediately lateral to the dorsum



Fig 1 Normal anatomy of the trigeminal region The dura is removed and the gasserian ganglion exposed on the left side

sellae and at the apex of the pyramid The so called 'ganglial part of the carotid siphon is located mainly below, medial, and close to the ganglion The ganglion receives its blood supply from small branches arising at the transition between the ganglial and cavernous sinus parts of the siphon (Figs 2 and 3) Small supply branches also come from the middle meningeal artery

Trigeminal neurinomas are very rare and comprise only 0 2 % of intra cranial tumors (SCHISANO & OLIVECRONA 1960) Nineteen proven cases of this type of tumor have been seen at Serafimerlasarettet and in 10 of these carotid angiography was performed

The ganglial part of the siphon, which is located extradurally, was in most cases displaced forwards, downwards, and medially, as would be expected from the anatomical relationship of the ganglion to the siphon This occurred in 6 out of 9 comparable cases and an example of this is shown in Fig 4 In one further case Case 4 in the table, only lateral projections were available for study and these showed similar anterior and downward displacement of the siphon The carotid siphon was displaced in a different manner in only 2 of the present 10 cases The typical forward and downward, but no definite medial, displacement was evident in Case 7 In Case 3 the typical medial displacement was seen but the siphon was displaced upwards and backwards indicating that the tumor was growing mainly below and anteriorly to the artery (Fig 5) There was no evidence of displacement of the ganglial part of the siphon in Case 10 but the presence of a small tumor in the floor of the middle fossa near the pyramidal apex was indicated by other roentgenographic signs The findings are collected in the table

Displacement of the intradural vessels in the present cases of trigeminal



Fig 2 Corrosion specimen of the base of the skull The carotid siphon and its small branches to the gasserian ganglion are seen F—foramen ovale P—proc clin ant S — sella

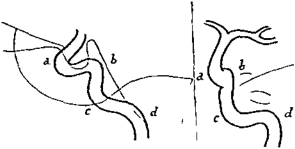


Fig 3 Diagrams of the carotid siphon lateral and a p a—b cavernous sinus part b—c ganglial part c—d intraosseous part.



Fig 4 Displacement of the ganglial part of the siphon

neurinomas was such that the Sylvian vessels anterior choroidal artery and basal vein were elevated in the same way as in basal tumors of the middle fossa in general This occurred in all cases

Abnormal vessels related to the tumor proper were evident in the majority of the cases and in 4 of them were large enough to be easily identified as vessels supplying the tumor These vessels arose from the internal carotid artery at the transition between the ganglial and cavernous sinus parts (see Figs 6 and 7) They were probably the vessels normally feeding the ganglion that were hypertrophied

Destruction of the tip of the pyramid was apparent in all cases

Table

Type of displacement of the carotid siphon in 10 cases of trigeminal neurinomas

	Case numbers									
	1	2	3	4	5	6	7	8	9	10
Forward	–	–	0	–	–		–	–	–	0
Backward	0	0		0	0	0	0	0	0	0
Downward	–	–	0	–	–		–	–	–	0
Upward	0	0	–	0	0	0	0	0	0	0
Medial	–						0	–	–	0
Lateral	0	0	0		0	0	0	0	0	0

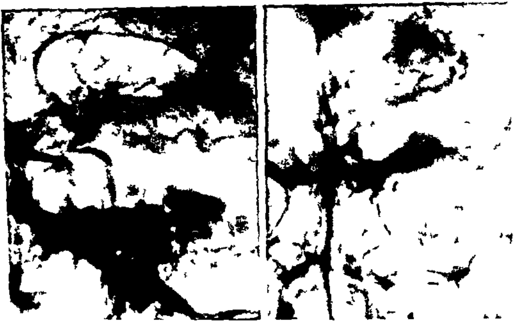


Fig 5 Case 3 Marked medial as well as backward displacement of the siphon

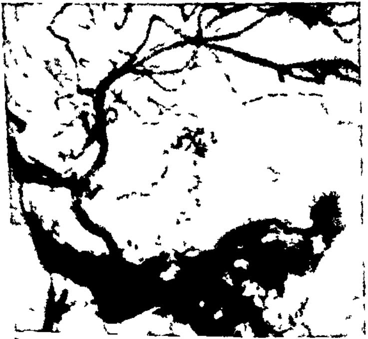


Fig 6 Trigeminal neurinoma Tumor vessels arising from the extradural part of the siphon are well demonstrated in the lateral view



Fig 7 Trigeminal neurinoma Tumor vessels arising from the extradural part of the siphon

Other tumors situated in the trigeminal region may give rise to changes similar to those seen in trigeminal neurinomas Carotid angiography was performed in 3 of the present 10 cases of chordomas in this region and in all of these the displacement of the siphon resembled the displacement that occurs in trigeminal neurinomas (Fig 8)

Chordomas producing evidence of destruction mainly in the midline and nodular, rather typical calcifications could usually be recognized as such Destruction in cases in which the growth grows more or less on only one side of the skull base may be very similar in both kinds of tumor and differentiation may be impossible unless the growth is calcified Three of the cases of chordoma had no calcifications, and in one of these merely a sharp edged clearly delimited bone defect in the apex of the pyramid was evident Carotid angiography was not performed and whether it would have contributed to the differential diagnosis is questionable

Well circumscribed tumors other than neurinomas apparently rarely ever arise in Meckel s cavity but if they do should produce the same bone changes and displace the carotid siphon in the same way as neurinomas The present writer has only one example of this a teratoma of the adult type that deformed the extradural part of the siphon by growing around it, the medial displacement was negligible

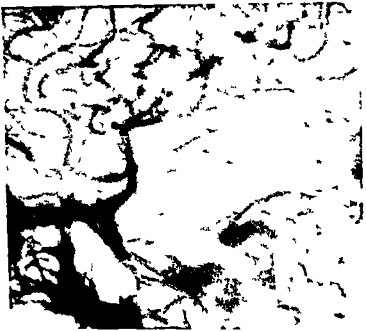
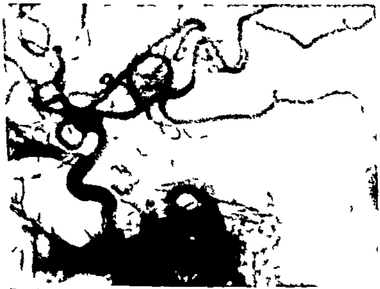


Fig 8 A case of chordoma with similar displacement of siphon and intradural vessels as in the tr geminal neurinoma



F g 9 Tento ial meningeoma growing between the dorsum sellae and petrous ridge suppl ed by branches from the siphon (No bone changes)

Abnormal vessels arising from the extradural part of the siphon, occurring in meningeomas, have been described by STATTIN (1961) A meningeoma of this type is shown in Fig 8 There was no such obvious displacement of the extra dural part of the siphon in any of our meningeoma cases in contrast to the neurinoma cases, but deformity of the wall was not uncommon as a sign of a tumor growing around the vessel

Conclusions

The roentgenologic signs of trigeminal neurinoma seem to be almost pathognomonic if the tumor is hypervascular, and if a well delimited bone defect is present If the tumor is avascular, every well circumscribed tumor arising in Meckel s cavity may produce the same appearances as trigeminal neurinoma and this holds true also for chordomas A differentiation must then be made on other grounds

SUMMARY

Angiographic changes in trigeminal neurinomas are described and the differential diagnostic possibilities are discussed

ZUSAMMENFASSUNG

Die angiographischen Erscheinungen des Trigeminusneuroms und deren Differentialdiagnose werden erortert

RÉSUMÉ

Description des signes angiographiques dans les neurinomes du trijumeau et discussion des possibilités du diagnostic différentiel

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FROM THE ROENTGEN DEPARTMENT (DIRECTOR PROF ERIK LINDGREN) OF SERAFIMERLASARETTET, STOCKHOLM, SWEDEN

ANGIOGRAPHY OF CEREBRAL METASTASES

by

LARS ZACHRISSON

Almost all authors on cerebral angiography agree that there is often difficulty in distinguishing between metastases and other intracerebral tumors It is usually considered that metastases on the basis of certain vascular characteristics may be divided into four groups (1) homogenous accumulation of contrast medium (as in meningeoma) (2) an avascular centre and a periphery rich in vessels (3) rather large irregular vessels often with arteriovenous fistulas (as in glioma) (4) network of delicate tortuous vessels

It has not been possible definitely to establish the origin of metastases from the appearances in cerebral angiography

Material The series of histologically verified brain metastases investigated in the roentgen department of Serafimerlasarettet is larger than any other reported in the literature The publication of observations made on this material would therefore appear to be justified The series consists of 124 cases investigated since 1937 During these 24 years methods of investigation have naturally improved so that the material is somewhat heterogenous by current standards many of the older investigations are incomplete

The main portion of the material is included in the following four groups carcinoma of the respiratory system (20 cases) hypernephroma (18 cases) carcinoma of the breast (18 cases), and melanosarcoma (16 cases)

The remainder of the diagnosed cases of primary tumor have been placed in a single group of 18 cases, as there are very few cases with a common primary diagnosis. The cases in this group consist of 7 cases of carcinoma of the alimentary tract, four of which are of the intestine and three of the stomach, 2 cases of carcinoma of the prostate gland, and 9 cases all of which have different primary diagnoses: chorionepithelioma, sarcoma, seminoma, teratoid tumor of the testis, carcinoma of the adrenal gland, carcinoma of the ovary, esophageal carcinoma, carcinoma of the pancreatic gland and carcinoma of the thyroid gland. There are, in addition, 34 cases in which the primary tumour was unknown.

In the whole material there are 24 cases of metastases from adenocarcinoma, which were placed in one group with a view to observe possible common changes; in 16 of these the primary tumor was not diagnosed.

Findings

The occurrence of pathologic vascularization in the total material of 124 cases is recorded below.

	Definite	Uncertain	Absent
Hypernephroma	17		1
Pulmonary carcinoma	10	2	8
Mammary carcinoma	4	—	14
Melanoma	4	1	11
Other cases of known primary tumor	10	—	8
Cases of unknown primary tumor	11	1	22
Total numbers	56	4	64

Metastases from hypernephroma. There are few references in the literature to the occurrence of pathologic vascularization in cerebral metastases from hypernephroma. DECKER & HEINY (1956) reported 14 cases, in six of which there was pathologic vascularization. According to MÜLLER (1958) this change occurred in 4 out of 8 cases. There were pathologic vessels in all our cases except one, i. e. in more than 90 %, in about a third of these, vessels similar to those of the primary tumor (but also to glioma) were evident (Fig. 1).

A more characteristic change in metastases from hypernephroma is perhaps contrast accumulation along the periphery of the tumor (Fig. 2). This was suggested by GLONING (1955) as a possible method of separating hypernephroma metastases from other types. Ten of our 18 cases of hypernephroma had this rather broad peripheral zone of contrast medium accumulations and a more or less avascular centre. If the tumor is extremely large the roentgen appearances will not be so characteristic. Only 2 other cases in our total series of metastases



Fig 1 A big metastasis from hypernephroma somewhat similar to the primary tumor in angiographic appearance numerous tortuous vessels small irregular pools of contrast medium early shunting into veins

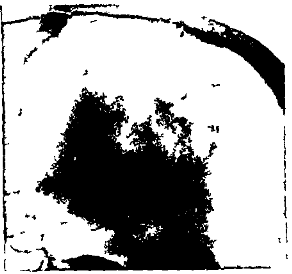


Fig 2 Metastasis from hypernephroma in the parietal lobe near the cortex Rounded tumor somewhat irregular with contrast medium mainly in the periphery

presented similar changes, one of these belonging to the group of unknown primary tumor, which might consequently have been a hypernephroma, the second case was histologically an adenocarcinoma This type of contrast medium accumulations in metastases is almost pathognomonic but occurs only in 50 % of hypernephroma metastases

Metastases from pulmonary carcinoma The second group with the occurrence of pathologic vascularization (see p 522) consists of metastases from carcinoma of the respiratory system Our series includes 20 cases, ten of which had pathologic vessels Since almost all these metastases had different histologic diagnoses it was not unexpected that there was no evidence of vascular changes common throughout the group In 4 of the 10 cases with pathologic vascularization a vein was clearly visible in the arterial phase and in 4 cases there were only faint traces of contrast medium No characteristic arterial changes were seen

Melanosarcoma metastases Only 4 cases presented evidence of pathologic vascularization There was a rapid circulation in all these 4 cases but faint contrast outline occurred in only 2 of the cases It was not possible to establish any characteristic vascular changes in these metastases, they were all rather similar to those seen in gliomas

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Fig 2 Metastasis from hypernephroma in the parietal lobe near the cortex Rounded tumor somewhat irregular with contrast medium mainly in the periphery

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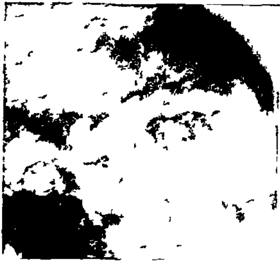


Fig 3 Metastasis histologically an adenocarcinoma No primary tumor was diagnosed Small irregular vessels in the tumor which is surrounded by large veins



Fig 4 Adenocarcinoma metastasis No primary tumor was diagnosed Wide veins surround the tumor

Metastases from carcinoma of the breast Only 4 among 18 cases of metastases from mammary cancer show pathologic vascularization In three of these, the intrinsic vascular changes were very slight, in 1 case only was there extensive intrinsic vascular changes

Metastases from adenocarcinoma There are as many as 24 cases, diagnosed as metastases from adenocarcinoma in this series, 10 had pathologic vascularization Peripheral veins surrounding the metastasis were evident in 3 cases and probably in 3 more (Fig 3) Such veins were found only in 4 other cases of our total series as may be seen below

	Definite	Probable	Absent
Adenocarcinoma	3	3	4
Hypernephroma	1	2	14
Pulmonary cancer	—	2	8
Melanosarcoma	—	2	2
Mammary cancer	—	1	3
Remaining cases	3	3	5

It would therefore appear probable that histologically more than 50 % of the metastases with surrounding veins are adenocarcinomas

Differential diagnosis of meningeomas and gliomas Most authors agree that there are certain characteristics that sometimes make it possible to separate brain metastases from other intracerebral tumors (ETHELBERG & VAERNET 1953

SCHIEFER, RAUSCH & UDVARHELYI 1955, GLONING 1955, TONNIS & SCHIEFER 1955 MILETTI 1950, LORENZ 1951, WICKBOM 1953) Multiplicity when it occurs is absolutely indicative It was found in 11 cases (about 10 %) in this series although generally only one hemisphere had been investigated Metastases are as a rule well defined and rounded and in most cases are situated in the terminal region of a given artery They often have a parietal and/or subcortical location and in many cases are surrounded by extensive edema, which gives the impression of a much larger tumor In metastases as in meningeomas, contrast filling often occurs in this material it occurred in about 65 % of the cases with a pathologic vascularization, as appears from the tabulation below

	Definite	Probable	Absent
Hypernephroma	11	3	4
Pulmonary cancer	4	2	14
Mammary cancer	2	1	15
Melanosarcoma	2	—	14
Remaining cases	11	6	35
Total	30	12	82

Differentiation of meningeomas The contrast medium filling of metastases begins early and is often of short duration, it is sometimes found only in two or three films in a serial investigation and thus lasts for only about a second Metastases are often very similar to meningeomas as regards filling but there are certain criteria that make it possible to distinguish between the two Thus, the filling in meningeomas starts later and is usually prolonged, unlike in metastases it increases during the venous phase The circulation through a meningeoma is usually slow, and drainage veins appear late in the arteriogram Furthermore except when intraventricular meningeomas are extracerebral with a broad base towards the cranium If a tumor exhibits only peripheral contrast medium filling at internal carotid angiography a more positive diagnosis may be attained by investigation via the external carotid artery

Differentiation of gliomas The differentiation of gliomas with pathologic vascularization is more difficult Features common to metastases and gliomas are an intracerebral location rapid circulation and tumor vessels There are however distinguishing features Gliomas seldom exhibit contrast filling and they grow by infiltration Metastases on the other hand are generally well outlined but frequently present regional changes caused by the surrounding edema Gliomas at the time of diagnosis are generally larger than metastases Variation in the size of the arterial lumen is seldom evident in metastases Many cases in which the differential diagnosis is impossible are of course encountered

Conclusions

It was possible in the present series to find criteria that made the diagnosis of metastasis fairly certain in 37 of 56 cases with pathologic vascularization Eleven of these were cases of multiple tumors, in another 8 cases the diagnosis was suggested The remainder (68 cases) exhibited no characteristic changes In 10 of the 37 cases mentioned, a definite diagnosis of hypernephroma was possible The diagnosis of an adenocarcinoma is fairly certain if veins surround the growth, other types of metastases exhibit no changes typical of the primary tumor

It would appear to the writer that the possibility of distinguishing metastases from other intracerebral tumors by cerebral angiography is greater than one has been led to believe A specific diagnosis could be made in about 70 % of the cases of the present material with pathologic vascularization It is much more difficult to establish the diagnosis of the primary tumor from the appearances of the metastases in the angiogram It was found possible to do this in the present series in 50 % of the cases of metastases from hypernephroma, but not in the other types of metastases

SUMMARY

A series of 124 cases of histologically verified cerebral metastases is analysed and discussed. It would appear that it is posssible to differentiate between metastases and other intracerebral tumors by cerebral angiography in seventy per cent of cases in which pathologic vascularization exists The nature of the secondary deposits may be determined in about half the cases if the primary growth is a hypernephroma

ZUSAMMENFASSUNG

124 Falle von histologisch kontrollierten Hirnmetastasen werden detailliert analysiert und besprochen Es erscheint möglich dass man in solchen Fallen in welchen pathologische Vaskularisation vorliegt zwischen Metastasen und Hirntumor in 70 % der Falle unterscheiden kann *Falls die Metastasen von einem Hypernephrom verursacht sind* können sie in etwa der Halfte von den Fallen als solche erkannt werden

RÉSUMÉ

L auteur analyse et discute une série de 124 cas de métastases cérébrales vérifiées histologiquement Il semble qu il est possible de distinguer les métastases des autres tumeurs intracérébrales par angiographie cérébrale dans soixante-dix pour cent des cas ou il existe une vascularisation pathologique La nature des tumeurs secondaires peut être décelée dans environ la moitié des cas quand la tumeur primitive est un hypernéphrome

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LES CAVITES CEREBRALES SUPPLEMENTAIRES PENDANT LE DEVELOPPEMENT FOETAL ET NEO FOETAL

par

J Baudy Pasquier et J C Larroche

Nous avons voulu preciser quelques aspects radiologiques particuliers aux encephalographies pendant la periode peri natale s etendant de 7 mois a 10 mois d age conceptionnel, c est a dire incluant les prematures de 7 mois jusqu aux enfants nes a 9 mois et ayant vecu 1 mois

Le cerveau a cette periode n est pas morphologiquement un cerveau d adulte en réduction Son evolution n est pas terminee En particulier il persiste encore souvent des cavites surnumeraires de la ligne médiane

Cavum septi lucidi ou 5eme ventricule cavum Vergae ou 6eme ventricule developpes au cours de l evolution des commissures cavum veli inter positi ou citerne du toit du 3eme ventricule d origine tout a fait differente puisque sous arachnoidienne

C est l anatomie de ces cavités leur frequence en fonction du terme et leur traduction radiologique que nous avons etudiées

L etude anatomique porte sur 83 cerveaux non specialement selectionnes d enfants mort nes ou ayant vecu moins de 15 jours

Les documents radiographiques comprennent 14 encephalographies fractionnees qui ont un aspect ventriculaire normal avec injection suffisante des

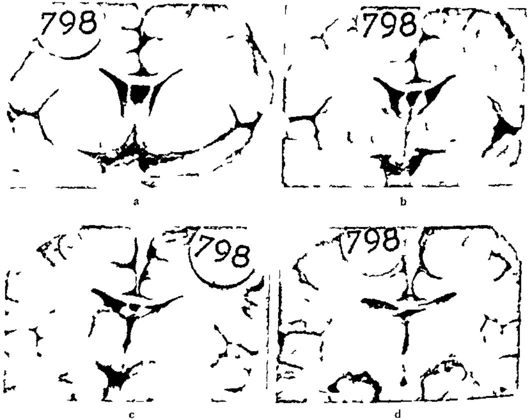


Fig 1 Coupes frontales a) Juste en avant du chiasma le cavum septi lucidi est large b) Le tuber cinereum et les trous de Monro le cavum septi lucidi se retrécit c) Les tubercules mammillaires on voit la coupe de l extremité postérieure du cavum septi lucidi d) Niveau de la protubérance le cavum septi lucidi n existe plus

espaces ventriculaires et sous arachnoidiens Cliniquement ces enfants présentaient tous de gros troubles neurologiques L aspect clinique le pronostic grave du point de vue developpement psycho moteur nous ont seuls autorisés a pratiquer cet examen Mais jamais nous n avons fait d encephalographies chez des enfants normaux

Ces deux séries d observations anatomiques et radiologiques ne sont pas exactement superposables puisqu il s agit d une part d un materiel d autopsie, et d autre part d encéphalographies faites du vivant de l enfant Mais devant une certaine concordance des résultats nous avons cru pouvoir rapprocher ces deux series

Le cavum septi lucidi anatomiquement s étend d avant en arriere, du genou du corps calleux a son sommet Il est situe entre les deux feuillets non accolés du septum (Fig 1)



Fig 2 Encephalographie fractionnee faite chez une fille de 2 mois née au term de 8 mois Rad o de face centree sur les ventricules latéraux décubitus Les cornes frontales sont ecartees (5 mm) traduisant ind rectement la presence d un cavum sep ti lucidi (Comparer à la coupe anatomique fig 1)

Dans aucun de nos cas le cavum septi lucidi ne communiquait avec les ventricules latéraux le 3eme ventricule ou avec l espace sous arachnoidien

La frequence du cavum septi lucidi en fonction du terme a ete etudiee

Il est pratiquement constant jusqu à 8 mois et demi en effet entre 6 mois et 6 mois 1/2, on le trouve 22 fois sur 24, de 6 mois 1/2 a 7 mois 1/2 on le trouve 21 fois sur 22, de 7 mois 1/2 a 8 mois 1/2 on le trouve 13 fois sur 14

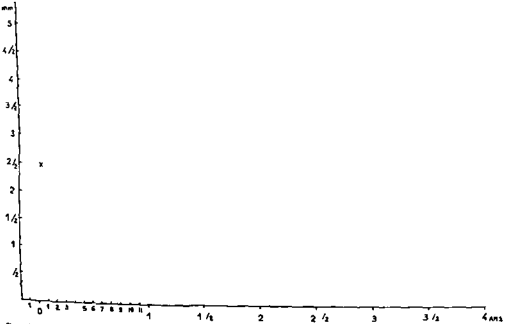


Fig 3 Nuage de dispers on des d tances entre les parois int rnes des ornes f ntal n urees sur les pneumoencephalographies d enfants de la naissance à 4 ans (ad os de face) Le < presentent les cas de la p riode n onatale etudies dans cet art cle Les points représ ntent des cas entre 2 mois et 4 ans dont les pneumoencéphalograph es prat quees dan un autre hop tal serv nt d eléments de co nparai son On voit que le septum est nettement plus large dans la per od neonatal qu apres 2 mois évoquant ind ectement la présence d un cavum septi lucid

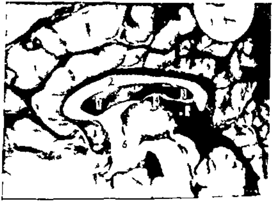


Fig 4 Face interne de l hémisphere droit coupe sagittale du tronc cerebral et du cervelet Enorme cavite correspondant dans sa partie anterieure au cavum septi lucidi et dans sa partie postérieure au cavum Vergae Ces deux cavités communiquent largement
1 — Cavum septi lucidi
2 — Corps calleux
3 — Cavum Vergae
4 — Cavum veli interpositi
5 — Citerne de la veine de Galien
6 — Paroi laterale du 3eme ventricule



Fig 5 Fragment posterieur d un hemisphere droit face interne Le cavum septi lucidi se prolonge par le cavum Vergae dont le plancher est decollable jusqu à la partie posterieure du corps calleux mais ne rejoint pas cependant le splénium comme dans la figure 4
1 — Extremite posterieure du cavum septi lucidi
2 — Cavum Vergae
3 — Corps calleux
4 — Splénium du corps calleux
5 — Couche optique
6 — Velum interpositum avec plexus choroides
7 — Citerne de la veine de Galien

Mais il existe moins souvent entre 8 mois 1/2 et 9 mois 1/2 18 fois sur 9?, et son diametre diminue Radiologiquement le cavum septi lucidi traduit sa présence non par une image aerique, puisqu il ne communique pas avec les autres cavites normalement remplies par l air, mais son volume se manifeste par un ecartement anormal des cornes frontales un aspect de septum large (Fig 2)

L epaisseur du septum a été mesuree sur une série de pneumoencephalographies qui presentaient des images ventriculaires normales de la naissance jusqu a 4 ans (Fig 3) C est dans la periode peri natale que se groupent les cas ou l image radiologique du septum dépasse 2 5 mm

Le cavum Vergae anatomiquement est situe en arriere du cavum septi lucidi Il est limite par le corps calleux, les piliers posterieurs du trigone et la commissure inter hippocampique Il se trouve juste au dessus du toit du 3ème ventricule En arriere il s applatit et est situé alors au dessus de la partie antérieure et supérieure de la citerne de la veine de Galien (Fig 4)

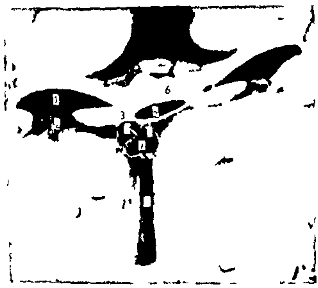


Fig 6 Coupe frontale en arrière du trou de Monro destinée à montrer les rapports du cavum Vergae et du cavum veli interpositi Le cavum Vergae ovalaire est situé entre les piliers postérieurs du trigone sous le corps calleux et au-dessus de la commissure hippocampique Juste en dessous se trouve le cavum veli interpositi situé entre les piliers postérieurs du trigone et la commissure hippocampique au-dessus le toit du 3ème ventricule au-dessous Latéralement il s étend jusqu aux plexus choroïdes des ventricules latéraux Plusieurs trabécules sont tendues entre les parois

1 — Ventricule latéral
2 — Plexus choroïde du ventricule latéral
3 — Pilier postérieur du trigone
4 — Cavum Vergae
5 — Commissure hippocampique
6 — Corps calleux
7 — Cavum veli interpositi
8 — 3ème ventricule
9 — Trabécules à l intérieur du cavum veli interpositi

Dans un seul cas il était nettement séparé du cavum septi lucidi Dans tous les autres cas il communiquait avec celui ci

Mais jamais nous n avons trouvé de communications avec les ventricules latéraux le 3ème ventricule ou les citernes environnantes

L étude de la fréquence du cavum Vergae avec l âge conceptionnel montre que sa régression se fait beaucoup plus tôt que celle du cavum septi lucidi Entre 6 mois et 6 mois 1/2 il est présent, mesurable 2 fois sur 19, à partir de 7 mois 1/2 on ne le trouve pratiquement plus

C est dire qu aux âges où l encéphalographie commence à être pratiquable il y a peu de probabilités pour qu il existe encore D autre part ne communiquant pas avec les espaces normalement injectés par l air sa traduction radiologique ne peut être qu indirecte Sa situation par rapport aux ventricules latéraux fait que son volume ne peut les déformer

Dans notre matériel radiologique nous n avons pas décelé sa présence

Par contre il existe sur la ligne médiane située juste en dessous du cavum Vergae une cavité sous arachnoïdienne très souvent béante à cet âge *le cavum veli interpositi* ou *citerne du toit du 3ème ventricule*

Anatomiquement cette cavité est située sous le trigone au dessus du toit du 3ème ventricule Elle peut se prolonger en avant jusqu aux trous de Monro et s ouvre en arrière dans la citerne de la veine de Galien (Fig 5) Elle est revêtue par de la pie mère qui s invagine en doigt de gant dans cette cavité



Fig 7 Encephalographie fractionnee chez une fille de 3. jours nee à terme même cas que figure 3 Radio de profil rayon horizontal enfant en position assise Cliche en cours de remplissage On voit le cavum veli interpositi qui commence à s injecter par les citernes ambiens alors que les ventricules lateraux contiennent encore tres peu d air
1 — Ventricules lateraux
2 — Cavum veli interpositi
3 — Citernes ambiens
4 — 4eme ventricule



Fig 8 Encephalographie fractionnee chez un garçon ne à terme et age de 20 jours Radio de profil decubitus rayon horizontal Le cavum veli interpositi est bien visible entre les ventricules lateraux et le 3em ventricule Il communique en arriere avec la citerne de la veine de Galien et le lac cerebelleux superieur Visibilite du cartilage d encroutement du sphenoide et du basi-occipital
1 — Cavum veli interpositi
2 — Citerne de la veine d Galien
3 — Lac cérébelleux superieur
4 — 3eme ventricule
5 — Aqueduc de Sylvius

De face elle s étend jusqu aux bords des ventricules lateraux, sous les piliers posterieurs du trigone (Fig 6) Il existe souvent des trabeculations qui la cloisonnent partiellement et qui au cours de l evolution la collabent le plus souvent Du fait qu elle communique largement avec les espaces sous-arachnoidiens par la citerne de la veine de Galien son image radiologique est directe

Elle se remplit en position assise par les citernes ambiens et la partie haute de la citerne de la veine de Galien Le cavum veli interpositi lorsqu il est completement injecte (Fig 7) atteint en avant la proximite des trous de Monro



Fig 9 Encéphalographie fractionnée chez une fille de 2 mois née au terme de 8 mois Radio de face decubitus Le cavum veli interpositi est visible entre les ventricules latéraux et le 3ème ventricule dont il est séparé par 1 mm environ

(Fig 8) En bas il est tres finement separe du 3eme ventricule, en arriere il est en pleine continuite avec la citerne de la veine de Galien et le lac cerebelleux superieur On peut voir l image negative de la veine de Galien, comme l a décrite ZELLWEGER

En procubitus elle se vide soit completement, soit incompletement dans le lac cerebelleux superieur

De face elle se projette au dessus du 3eme ventricule, et s etend souvent assez loin lateralement (Fig 9)

Conclusion

Cette etude montre qu il peut exister normalement dans la periode perinatale des cavités de la ligne médiane cavum septi lucidi et cavum Vergae qui lorsqu elles persistent chez le plus grand enfant et l adulte, deviennent des malformations mineures

D autre part du point de vue radiologique les seules images aeriques supplementaires de la ligne mediane sont celles du cavum veli interpositi puisque le cavum septi lucidi et le cavum Vergae ne peuvent etre remplis d air

Enfin dans cette periode les cornes frontales sont souvent plus ecartees que par la suite traduisant l existence normale a cet age du cavum septi lucidi

RÉSUMÉ

Le cavum *septi lucidi* et le cavum Vergae ont été étudiés sur 83 cerveaux entre 6 et 9 mois d age conceptionnel Ces cavités ne communiquent jamais avec les espaces ventriculaires Aux *environs* du terme le cavum Vergae est généralement collabé alors que le cavum septi lucidi existe encore frequemment Quatorze encéphalographies fractionnées pratiquées chez des nouveaux nés aux environs du terme ont été examinées parallèlement Le cavum septi lucidi se traduit indirectement par l ecartement des cornes frontales Une cavité sous arachnoidienne le cavum veli *interpositi* est souvent injectée d air et ne doit pas être confondue avec le cavum Vergae

SUMMARY

The *fifth and sixth ventricles were studied in 83 brains from the 6th to 9th month of intra* uterine life These cavities never communicate with the ventricular spaces Approaching term the sixth ventricle is generally collapsed while the fifth ventricle is often still formed Fourteen encephalographies performed in new borns just after birth were compared The fifth ventricle is indirectly shown by the separation of the anterior horns A subarachnoidal cavity lying in the tela choroidea is often filled with air and should not be mistaken for the sixth ventricle

ZUSAMMENFASSUNG

Der 5 und 6 Ventrikel wurden an 83 Gehirnen vom 6 —9 Fotelmonat studiert Diese Hohlraume kommunizieren niemals mit den Ventrikelraumen Zur Zeit des Geburtstermins ist der 6 Ventrikel im allgemeinen kollabiert während der 5 Ventrikel noch immer sichtbar ist Es werden 14 encephalographische Untersuchungen am Neugeborenen unmittelbar im Anschluss an die Geburt miteinander verglichen Der 5 Ventrikel ist indirekt durch den vergrosserten Abstand zwischen den Vorderhornern nachweisbar Oft erhält man einen subarachnoidalen Raum in der Tela choroidea luftgefullt der nicht mit dem 6 Ventrikel verwechselt werden sollte

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RADIOLOGIC FINDINGS IN TEMPORAL LOBE EPILEPSY OF NON TUMORAL ORIGIN

by

GUIDO CASTORINA and DONALD L. McRAE

In so called temporal lobe seizures, the first phenomenon is often a smell a taste a sound, an illusion or a hallucination dizziness a sensation in the epigastrium rising upwards behind the sternum loss of contact or lack of awareness often with some type of automatic behavior Seizures of this pattern usually come from the parts of the brain in and just above the middle fossa, i e the temporal lobe the insula (island of Reil) and the adjacent parts of the frontal and parietal lobes

The electroencephalogram usually is reported as showing a lesion of the temporal lobe The electrocorticogram sometimes shows a lesion deep in the temporal lobe (uncus hippocampus and amygdaloid nucleus) In other cases it shows a lesion on the surface of the temporal lobe and in still other cases it shows a lesion of the adjacent parts of the frontal or parietal lobes or the insula

Many different lesions may *produce so called temporal lobe seizures* They can be divided into two broad groups tumors (gliomas meningiomas angiomas etc) and non tumoral lesions (hamartomas areas of gliosis non gliomatous cysts etc) In the second group the temporal lobe may appear grossly normal yet the neurosurgeon may get the impression that it is tough and sclerotic In many of these cases the pathologist finds incisural sclerosis but in others the brain appears microscopically normal In spite of this temporal lobectomy often produces good results

SUMMARY

The fifth and sixth ventricles were studied in 83 brains from the 6th to 9th month of intra uterine life These cavities never communicate with the ventricular spaces Approaching term the sixth ventricle is generally collapsed while the fifth ventricle is often still formed Fourteen encephalographies performed in new borns just after birth were compared The fifth ventricl is indirectly shown by the separation of the anterior horns A subarachnoidal cavity lying in the tela choroidea is often filled with air and should not be mistaken for the sixth ventricle

ZUSAMMENFASSUNG

Der 5 und 6 Ventrikel wurden an 83 Gehirnen vom 6—9 Fotelmonat studiert Diese Hohlraume kommunizieren niemals mit den Ventrikelraumen Zur Zeit des Geburtstermins ist der 6 Ventrikel im allgemeinen kollabiert wahrend der 5 Ventrikel noch immer sichtbar ist Es werden 14 encephalographische Untersuchungen am Neugeborenen unmittelbar im Anschluss an die Geburt miteinander verglichen Der 5 Ventrikel ist indirekt durch den vergrosserten Abstand zwischen den Vorderhornern nachweisbar Oft erhalt man einen subarachnoidalen Raum in der Tela choroidea luftgefullt der nicht mit dem 6 Ventrikel verwechselt werden sollte

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Fig 1 *Case 53* Female aged 15 Thickening and flattening of the left side of the cranial vault slight relative elevation of floor of left middle fossa and slight relative enlargement of all parts of left lateral ventricle Left craniotomy disclosed many small tough gyri in the frontal and Rolandic regions as well as incisural sclerosis of temporal lobe

12 Smoothness of one petrous ridge
13 Elevation of one petrous ridge
14 Depression of one petrous ridge
15 Unilateral elevation of the great wing of the sphenoid bone
16 Unilateral shallow middle fossa
17 Unilateral short middle fossa

Changes (1) to (6) refer to the cranial vault Changes (7) to (17) refer to the base of the skull, (7) (8) (9) and (10) indicating smallness of the anterior fossa while changes (11) to (17) indicate smallness of the middle fossa

Pneumoencephalographic changes in established atrophy or hypoplasia of one cerebral hemisphere are

1 Ipsilateral large lateral ventricle
2 Ipsilateral local ventricular enlargement
3 Septum pellucidum towards ipsilateral side
4 Third ventricle towards ipsilateral side
5 Ipsilateral enlarged subarachnoid sulci
6 Non filling of ipsilateral subarachnoid sulci

Many combinations of the above mentioned changes in the skull and encephalogram were seen in these patients (see appendix) The complete picture showed thickening of the ipsilateral cranial vault smallness of the ipsilateral middle fossa enlargement of the ipsilateral lateral ventricle most marked in the temporal horn shift of the septum pellucidum and 3rd ventricle towards the abnormal side and either enlargement or non filling of the subarachnoid sulci of the abnormal cerebral hemisphere (Fig 1) However,

When the seizures are not due to tumor or angioma, the clinical, radiologic and electroencephalographic findings may not correlate well with each other. The radiologic changes may be slight, and considered individually might be taken as normal variants. For this reason, a study of almost 200 consecutive patients with temporal lobe seizures was undertaken. In this group there were 100 patients who were subsequently operated upon and in whom no tumor or angioma was found.

The patients had had skull films (including films of the base) and encephalograms. A few had had carotid angiograms. The skull was examined with stereoscopic a.p. views in Ruggles' projection (fronto occipital, 15°), single or stereoscopic Caldwell's projections (occipito frontal, 12°), stereo-axial views of the base to show the middle fossa (submento vertical, 80°) and stereoscopic lateral views made as follows.

The first film was made with the central ray passing through a point one inch above and anterior to the external auditory canal. The second film was made with the tube moved towards the top of the head and tilted so that the central ray was directed slightly towards the feet. The encephalograms were carried out using large amounts of oxygen, from 60 to 120 ml. Particular care was taken to fill the temporal horns completely with gas.

The lateral films to show the temporal horns were made as follows. The first film of the stereoscopic pair was made with the head resting on the side, the mid sagittal plane exactly horizontal, the interorbital line vertical and the central ray passing through a point one inch anterior and superior to the external auditory canal. The second film was made after the roentgen tube had been moved towards the feet 10 % of the focal film distance and the cone angled slightly towards the head. The patient was then turned into the supine position for a.p. projections of the temporal horn.

Many abnormalities may be seen on ordinary skull roentgenograms of patients with epilepsy of non tumoral origin. The bony abnormalities are as follows.

1. Unilateral flatness of the cranial vault, frontal, parietal or temporal.
2. Unilateral thickness of the cranial vault, frontal, parietal or temporal.
3. Unilateral smoothness of the inner surface of the vault, frontal, parietal or temporal.
4. Localized thinning and bulging of the vault.
5. Localized roughness of the inner surface of the vault.
6. Lateral displacement of the groove of the superior longitudinal sinus.
7. Moderate to marked unilateral hypertrophy of frontal and/or ethmoid sinuses.
8. Upward tilt of one side of the planum sphenoidale.
9. Upward tilt of one lesser wing of the sphenoid bone.
10. Lateral deviation of the crista Galli.
11. Unilateral hypertrophy of mastoid and/or petrous cells.



Fig 3 *Case 81* Male aged 25 seizures since 13 years of age The two sides of the cranial vault were of equal thickness and the floors of the middle fossa at the same level The encephalogram showed all parts of the right lateral ventricle to be enlarged Falx septum pellucidum and 3rd ventricle were all closer to the right side of the skull Right craniotomy revealed a large area of destruction on the lateral surface of the brain involving the middle portion of the temporal lobe and the adjacent portions of the opercula of the frontal and parietal lobes The destroyed brain was replaced by a large cyst filled with cerebrospinal fluid

in which good correlation was present and 47 cases with adequate correlation, a total of 79 % in which the radiologic findings pointed to the side of the brain which was later subjected to operation In 10 cases, the radiologic findings were either normal or ambiguous and in 10 the radiologic findings suggested greater atrophy on the side of the brain opposite to the side of the brain operated on

If we consider the radiologic findings referring only to the middle fossa of the skull and to the temporal horn of the ventricular system (Table 1) the figures are almost the same They show improvement in good correlation There were 49 cases in which the signs of atrophy in the region of the temporal

Table 1

Radiologic findings in temporal lobe epilepsy of non tumoral origin

Correlated with	Good	Adequate	Normal or ambiguous	Opposite
side of operation	32 (++++)	47 (Mostly +)	10 0000 — 2 0?0? — 2 Ambiguous — 6	10 Mostly —
ipsilateral temporal lobe	49 Last column ++	30 Last column 0+) 29 +0) + 1	14 Last column +—) 3 —+) 00 8 0 3	7 Last column —0) 4 0—) —— 3

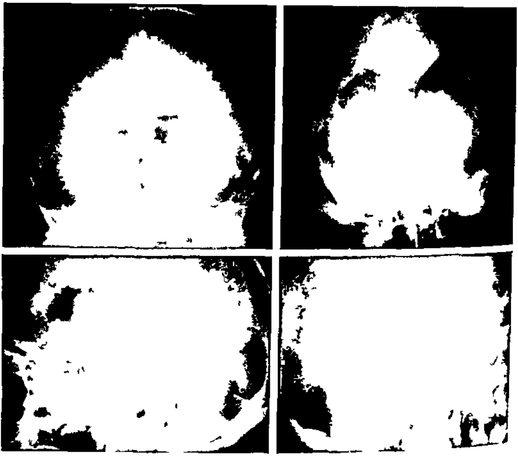


Fig 2 *Case 87* Male aged 39 seizures since one year of age Right side of cranial vault slightly thicker and flatter than left side yet anterior horn and body of right ventricle slightly smaller than on the left Right middle fossa was short on the basal views of the skull and right temporal horn slightly larger than left Right craniotomy revealed gliosis of the hippocampal gyrus, hippocampus and amygdaloid nucleus

the complete picture was present in only one—third of the patients In about half of the patients the picture was incomplete but adequate to point to the abnormal cerebral hemisphere Various combinations of adequate findings are illustrated in Figs 2 and 3 In 10 % of the patients, the complete picture was present but it pointed to the cerebral hemisphere opposite to the one that was subsequently operated on (Fig 4) There are several explanations for this which will be discussed later Finally in 10 % of patients, the radiologic findings were entirely normal or else the picture was ambiguous By ambiguous we mean that some abnormalities suggested hypoplasia or atrophy in one cerebral hemisphere but other abnormalities suggested hypoplasia or atrophy in the other cerebral hemisphere (Figs 5 and 6)

When we study the relation between the side of subsequent operation and the radiologic findings (Table 1) we find that there were 32 of the 100 cases



Fig 4 *Case 88* Male aged 31 seizures since 5 years of age The left side of the cranial vault was fairly thick and left side of base of skull slightly high in the anterior middle and posterior fossae All parts of left lateral ventricle were somewhat large Right craniotomy revealed the first temporal convolution to be small and its middle portion gliosed Alternating tough and gelatinous areas were found in the uncus hippocampus and amygdaloid nucleus

vault and to a lesser extent of enlargement of the body of the contralateral ventricle We can only say that in some cases of so-called temporal lobe epilepsy radiologic changes were predominantly in or limited to the middle fossa of the skull and the temporal horn of the ventricle In other cases there were accompanying abnormalities of the cranial vault and/or the body of the lateral ventricle These accompanying changes were sometimes ipsilateral and sometimes contralateral

In order to better show the differences we present Table 2 where the individual findings of the groups of cases with the same changes are shown The cases are divided according to the side of operation and show that there is some difference between the apparent accuracy of the radiologic findings in cases with right temporal lobe epilepsy from those with left temporal lobe epilepsy There is better correlation when the operation is later carried out on the left side than when it is later carried out on the right side of the brain When operation was carried out on the left side there were 22 cases out of 59 with ipsilateral radiologic abnormalities in the vault and the base of the skull as well as in the body and temporal horn of the lateral ventricle However when operation was later carried out on the right side there were only 10 cases out of 41 in which there were ipsilateral abnormalities of the vault the base the body of the lateral ventricle and the temporal horn It was also noted that in 10 cases (8 for left side operation and two for right side operation) the correlation with the side of operation was due mainly to alterations of the

Table 3

Radiologic findings in temporal lobe epilepsy of non tumoral origin

A *Skull findings*

	Positive correlation				Normal	Ambiguous		Opposite			
	++	0+	+0	Total	°	00	−+	+−	−0	0−	−−	Total
Left craniotomy	38	5	4	47	80	10	1	0	0	1	0	59
Right craniotomy	16	5	2	23	57	9	1	0	2	0	6	41
Total	54	10	6	70	70	19	2	0	2	1	6	100

B *Encephalogram findings*

	++	+0	+0	Total	°	00	−+	+−	−0	0−	−−	Total
Left craniotomy	30	5	9	44	80	4	4	0	2	0	1	55
Right craniotomy	16	5	6	27	71	3	5	0	1	0	5	41
Total	46	10	15	71	71	7	9	0	3	0	6	96

vault and the body of the lateral ventricle rather than to alterations of the floor of the middle fossa or of the temporal horn

Very often in the analysis of radiologic findings, the problem of the importance of either the skull or of the encephalogram in indicating the side of operation arises To investigate this possible difference we analyzed separately the findings of the examination of the skull and the findings of the pneumoencephalograms (Table 3) Cases with left and right side operation were separated in Table 3 In the skull analysis, the first symbol +, 0 or − indicates the findings in the cranial vault and the second symbol indicates the findings in the middle fossa In the analysis of the findings of the pneumoencephalograms, the first symbol indicates alteration in the body of the lateral ventricle and the second indicates changes pertaining to the temporal horn There are several combinations of changes, e g cases with all findings in the ipsilateral vault and ipsilateral middle fossa (++), cases with findings limited to the ipsilateral middle fossa (0+) cases with findings limited to the ipsilateral cranial vault (+0) There were also cases showing normal findings (00) and cases with ambiguous radiologic findings such as thickness of the contralateral side of the cranial vault but smallness of the ipsilateral middle fossa (−+) and vice versa (+−) Finally, there were some cases with signs pointing more or less completely to atrophy of the cerebral hemisphere on the side opposite to the operation side These were recorded as follows thick contralateral cranial vault with normal middle fossa (−0), normal vault with elevated floor of contralateral middle fossa (0−) or signs pointing to the contralateral vault and base (− −)

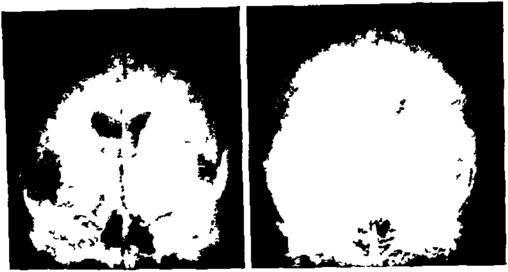


Fig 5 *Case 7?* Male aged 24 seizures since 6 years of age The left side of the cranial vault was thicker and flatter than the right, and the floor of the skull higher on the left than on the right in the anterior middle and posterior fossae The encephalogram showed relative enlargement of all parts of the right lateral ventricle Right craniotomy revealed moderate gliosis of the first temporal convolution and marked gliosis of the uncus

We made a similar analysis of the findings on the pneumoencephalogram Four of the cases had had pneumoencephalograms done at other hospitals and they were not available for analysis, or the temporal horns were not demonstrated For this reason there were only 96 encephalograms suitable for analysis

As appears from Table 3 there were 47 cases with good or fairly good correlation between the side of operation and the findings on the ordinary skull roentgenograms in the 59 cases in which operation on the left side of the brain was performed This is 80 % positive correlation However in the cases which were later operated upon on the right side there were only 23 out of 41 (57 %) that showed good or fairly good correlation between the skull changes and the side of operation The difference between the results of the investigation of the cases submitted to operations on the right and left sides of the brain increases if we consider only cases with findings both in the ipsilateral cranial vault and the ipsilateral middle fossa (38 out of 59 cases operated upon on the left side or 64 % but only 16 out of 41 cases operated on on the right side or 39 %)

It will further be noted in Table 3 that there were 19 cases in which the skull roentgenograms were normal 10 of these later receiving operation on the left side of the brain and nine later being operated upon on the right side There were eight cases in which the radiographic changes in the skull suggested

Table 3

Radiologic findings in temporal lobe epilepsy of non tumoral origin

A *Skull findings*

	Positive correlation					Normal	Ambiguous		Opposite			
	++	0+	+0	Total	/	00	—+	+—	—0	0—	——	Total
Left craniotomy	38	5	4	47	80	10	1	0	0	1	0	59
Right craniotomy	16	5	2	23	57	9	1	0	2	0	6	41
Total	54	10	6	70	70	19	2	0	2	1	6	100

B *Encephalogram findings*

	++	+0	+0	Total	%	00	—+	+—	—0	0—	—	Total
Left craniotomy	30	5	9	44	80	4	4	0	2	0	1	55
Right craniotomy	16	5	6	27	71	3	5	0	1	0	5	41
Total	46	10	15	71	71	7	9	0	3	0	6	[illegible]

vault and the body of the lateral ventricle rather than to alterations of the floor of the middle fossa or of the temporal horn

Very often in the analysis of radiologic findings, the problem of the importance of either the skull or of the encephalogram in indicating the side of operation arises To investigate this possible difference we analyzed separately the findings of the examination of the skull and the findings of the pneumoencephalograms (Table 3) Cases with left and right side operation were separated in Table 3 In the skull analysis, the first symbol +, 0 or — indicates the findings in the cranial vault and the second symbol indicates the findings in the middle fossa In the analysis of the findings of the pneumoencephalograms, the first symbol indicates alteration in the body of the lateral ventricle and the second indicates changes pertaining to the temporal horn There are several combinations of changes e g cases with all findings in the ipsilateral vault and ipsilateral middle fossa (++), cases with findings limited to the ipsilateral middle fossa (0+), cases with findings limited to the ipsilateral cranial vault (+0) There were also cases showing normal findings (00) and cases with ambiguous radiologic findings such as thickness of the contralateral side of the cranial vault but smallness of the ipsilateral middle fossa (—+) and vice versa (+—) Finally, there were some cases with signs pointing more or less completely to atrophy of the cerebral hemisphere on the side opposite to the operation side These were recorded as follows thick contralateral cranial vault with normal middle fossa (—0), normal vault with *elevated* floor of contralateral middle fossa (0—) or signs pointing to the contralateral vault and base (— —)

Table 4

Radiologic findings in temporal lobe epilepsy of non tumoral origin

A *Skull findings*

	Ipsilateral findings		Contralateral and ambiguous findings	
	Vault	Middle Fossa	Vault	Middle Fossa
Left craniotomy	42 = 71	43 = 74	1 = 2 *	1 = 2
Right craniotomy	19 = 46	21 = 51	8 20	5 = 12
Total	61	64	9	6

B *Encephalographic findings*

	Ipsilateral findings		Contralateral and ambiguous findings	
	Body of ventricle	Temporal horn	Body of ventricle	Temporal horn
Left craniotomy	39 = 71	35 = 64 *	7 = 13	1 2
Right craniotomy	21 = 51	21 = 51	11 = [illegible]	5 = 9
Total	60	56	18	6

roentgenograms the analysis of the pneumoencephalogram showed more signs pointing to the side opposite operation when the right side was subsequently operated upon This difference is more striking if we consider only the cases where there were changes in both the body of the lateral ventricle and in the temporal horn namely five cases receiving right side craniotomies but only one receiving a left side craniotomy

If we compare the groups of cases with good or fairly good bone changes on the ipsilateral side (70 cases) with those who had good or fairly good encephalographic changes (71 cases) we do not see any difference If we compare the cases who had ipsilateral bony changes with those who had enlargement of the entire ipsilateral ventricle we see that the number of cases with ipsilateral skull changes is slightly greater than the number of cases with encephalographic changes (54 to 46)

In comparing the data of skull radiography and encephalography we found two other differences First we found 19 cases in which skull examination was normal but only 7 cases in which the encephalogram was normal The most striking difference was in the cases with ambiguous findings Only two cases had ambiguous bony changes but nine had ambiguous encephalographic changes All the nine ambiguous encephalograms showed enlargement of the contralateral ventricular body and enlargement of the ipsilateral temporal horn

The presence of these cases and also the cases with ipsilateral findings only in the vault or only at the base of the skull raises the question of whether these

are real differences in figures and if so why they are found These findin
are analysed in Table 4, from which can be derived that in cases with go
correlation between radiologic findings and the side of operation, the differen
between the changes in the vault and the changes in the middle fossa (
versus 64), or between the findings in the ventricular body and in the tempor
horn (60 versus 56), is not important The figures pertaining to the tempor
horn are in the encephalograms about the same as those pertaining to th
middle fossa (56 to 64) We found in the analysis of the cases with ambiguo
or opposite findings that the number of signs pointing to the opposite ve
tricular body were much more numerous than those pertaining to the opposi
temporal horn (18 to 6) This brings up the possibility of contre-coup injur
to the brain producing atrophy in the superior part of the brain on one sid
and the inferior part of the brain on the other side

In Case 76 (see appendix) the radiologic findings suggested atrophy on th
opposite side because an intraventricular scar partly obliterated the ipsilatera
temporal horn In Case 57, an intracerebral cyst compressed the body o
the ipsilateral lateral ventricle In Cases 61 and 97 the temporal horns seeme
equal, yet at operation intracerebral cysts were found which probably prevent
ed enlargement of the adjacent temporal horns There were 10 intracerebra
cysts found in the 100 cases operated upon, and in at least three of these the
interfered with the radiologic interpretation

The presence or absence of displacement of the septum pellucidum and 3rd ventricle ma
be difficult to determine because of cranial asymmetry We tried to decide this point b
measuring the septum pellucidum in relation to the two sides of the frontal bone and also b
comparing it with the position of the falx In 36 of 96 encephalograms the septum pellucidu
was displaced towards the side of subsequent operation and in 18 the 3rd ventricle was dis
placed towards that side In ten of the 96 encephalograms the septum pellucidum was dis
placed away from the side of subsequent operation and in six the 3rd ventricl was displaced
away from that side In none of these was the septum pellucidum or 3rd ventricle of decisi
value but in some cases it was of confirmatory value particularly in ambiguous cases

Different degrees of filling of the subarachnoid sulci were fairly common in these cases
Sometimes the ipsilateral sulci did not fill with gas presumably because subarachnoid adhesions
filled them or prevented gas from reaching them In other cases the ipsilateral sulci f d
well and in some of these the ipsilateral sulci were enlarged In twenty four of th 96 en
cephalograms there were fewer sulci on the ipsilateral side and in thirteen there were more
and/or larger sulci on the ipsilateral side Asymmetry of the sulci must be considered a s
of abnormality but it is not of much help in choosing which is the abnormal side unless ther
is a localized group of enlarged sulci

Discussion

Many different diseases may produce epileptic seizures Some of these
diseases are diseases of the brain and some are outside of the brain (diabetes
hypertension etc) Therefore the pathologic and radiologic findings in epilep ic
patients are variable and even in a group of patients with focal epilepsy du
to non tumoral disease of the brain they vary considerably This is not sur

prising since these variations are great also in other neurological syndromes such as spastic diplegia infantile hemiplegia (FORD 1952)

A patient may have a small atrophic lesion in one cerebral hemisphere which is producing recurrent epileptic seizures and a larger atrophic lesion in the other cerebral hemisphere which is producing no seizures The radiologic changes due to the larger atrophic lesion show a positive correlation with the large pathologic lesion but they show a negative correlation with the epileptic seizures Therefore we must never report the radiologic findings as indicating an epileptogenic lesion or as indicating epilepsy

A patient may have an atrophic lesion of an unusual nature which may produce confusing radiologic changes For example intraventricular adhesions or inert intracerebral cysts may cause smallness of part or all of one lateral ventricle and cause the radiologist to diagnose atrophy of the opposite cerebral hemisphere

Approximately 15 % of cases with no symptoms or signs of neurologic disease had asymmetry of the vault and/or the base of the skull When it is of the type that is probably due to cerebral hemi atrophy we found more cases suggesting smallness of the left cerebral hemisphere than of the right

With these facts in mind the question arises if we can derive any useful information from the figures relating to the patients with so-called temporal lobe epilepsy of non tumoral origin Approximately 80 % show some radiologic signs of hypoplasia or atrophy of the lobe or hemisphere which is producing the seizures This is a significant number of positive correlations but not very valuable since some of these show but few radiologic changes However there were 32 patients in whom all radiologic changes were ipsilateral (++++) and only three in whom all radiologic changes were contralateral (— — — —) Therefore we conclude that the skull and ventricular changes are of value when they are present in all areas on one side of the head Forty nine patients with this syndrome showed relative smallness of the ipsilateral middle fossa and also relative enlargement of the ipsilateral temporal horn but only three showed such changes on the contralateral side Therefore we conclude that a small middle fossa and a large ipsilateral temporal horn are of value in such cases There were ten patients who showed relative enlargement of the body of the ipsilateral ventricle and thickening of the ipsilateral cranial vault with little or no change in the region of the temporal lobe We assume these patients have predominant atrophy in the insula or the frontal and parietal lobes rather than in the temporal lobe even though they had so called temporal lobe epilepsy

Acknowledgement

This work was assisted by a grant from the James Picker Foundation for Radiological Research

Appendix

The following symbols were used in the appendix In the column ipsilateral vault the sign + indicates that the cranial vault on the side of subsequent operation was thicker and or flatter and/or smoother on the inner surface than the contralateral vault The sign — indicates that the contralateral vault was thicker while the sign 0 means that the two sides of the cranial vault appeared the same In the columns ipsilateral middle fossa ipsilateral body of ventricle and ipsilateral temporal horn the symbol L indicates that the structure on the side of subsequent operation was larger than the similar structure on the opposite side The symbol S indicates that the structure was smaller than on the opposite side while the sign 0 indicates that the structure was the same size as on the opposite side The symbol ? means that no encephalogram was done or that the structure was not demonstrated In the columns septum pellucidum and third ventricle the symbol T means that the structure was displaced towards the side of subsequent operation The symbol A means that the structure was displaced away from the side of operation and 0 means that the structure was not displaced In the column sulci M indicates that more and/or larger gas filled sulci were visible on the cerebral hemisphere that was subsequently operated on while F indicates fewer and/or small gas filled sulci on that hemisphere

In the column correlation side only the first symbol + 0 or — indicates positive correlation normal findings or negative correlation respectively between the thicker side of the cranial vault and the side of subsequent operation The second symbol + 0 or — indicates positive correlation normal findings or negative correlation respectively between the larger lateral ventricle and the side of operation

In the column correlation temporal lobe the first symbol indicates positive correlation normal findings or negative correlation between the smaller middle fossa and the side of subsequent operation The second symbol indicates the correlation between the larger temporal horn and the side of operation

Case No	Age	Age at onset	Ipsil vault	Ipsil middle fossa	Ipsil ventr body	Ipsil temp horn	Sept pelluc	3rd ventr	Sulci	Operation side	Correlation	
											side only	temp l be
1	19	12	+	S	0	L	0	0	F	I	+0	−
3	14	8	+	0	L	L	T	T	0	I	+0	0+
8	27	14	0	0	S	S	0	0	F	I	0—	0—
9	30	14		S	I	L	T	0	F	I	++	−
10	21	12	−	S	0	0	0	0	0	I	−0	0
12	17	10	−	S	I	L	0	0	F	I	−−	+
13	28	2		S	S	S	0	0	0	R	+—	—
17	15	12	—	S	I	0	A	0	F	I	—	0
18	37	23	0	S	L	0	T	0	M	R	0+	+0
20	28	24	+	S	0	L	0	0	F	I	+0	
24	38	35	0	0	I	I	0	0	0	R	0+	0
25	22	9	−	S	I	L	T	0	M	I	++	−
26	41	27	−	S	I	I	0	0	F	I	−−	−
28	53	48	0	0	0	0	0	0	0	I	00	00
29	40	2	−	S	L	L	0	0	F	I	++	
32	37	26	0	0	0	0	0	0	0	R	00	00
34	39	25	0	0	L	0	0	0	0	I	0+	00
37	48	44	0	0	I	L	A	0	F	I	0+	0
40	29	1 mth	−	S	S	L	T	0	0	I	——	
42	29	24	+	0	S	0	0	0	0	R	+—	00
43	35	7	−	S	I	I	T	0	0	I	+	

Case No	Age	Age at onset	Ipsil vault	Ipsil middle fossa	Ipsil ventr body	Ipsil temp horn	Sept pelluc	3rd ventr	Sulci	Operation side	Correlation side only	Correlation temp lobe
44	18	5	−	S	I	0	T	0	M	I	+ +	−0
45	23	17	0	S	L	L	0	0	0	L	0 −	− +
46	28	18	0	S	L	I	T	T	0	L	0 +	− −
47	25	14	+	S	?	?	?	?	?	L	− ?	+
48	48	16	0	0	L	L	0	0	M	L	0 −	0 −
50	25	3	0	0	S	0	0	0	0	L	0 —	00
51	28	19	+	S	L	0	0	0	F	I	+ —	−0
52	30	20	+	S	L	1	?	0	0	R	+ −	− −
53	15	2	+	S	L	L	T	0	0	L	− +	− +
54	24	8	+	S	L	L	T	0	0	I	+ −	− −
55	12	7 mths	−	S	L	L	T	0	F	R	− −	− −
56	21	15	0	0	L	0	0	0	0	R	0 −	00
57	32	18	+	S	S	L	0	0	0	L	+ —	+ −
58	18	5	0	0	S	S	0	0	0	R	0—	0—
59	39	31	+	S	S	L	0	0	0	L	+ —	+ −
60	12	7 mths	+	S	L	L	T	T	0	R	+ +	− −
61	38	36	+	S	L	0	T	T	M	L	+ +	+0
62	28	26	+	S	0	L	A	A	F	L	+0	+ +
63	14	7	+	S	L	L	0	0	M	R	+ +	+ −
64	24	2	−	L	S	S	T	0	F	R	——	——
65	27	6	+	S	L	L	0	0	0	L	+ −	+ −
66	31	17	+	S	L	I	\	A	F	I	− +	− −
67	35	1	—	0	S	L	T	0	M	R	——	0 −
68	41	27	—	0	S	L	T	T	F	R	——	− +
69	51	36	0	0	S	L	T	T	0	R	0 −	0 +
70	16	8	+	S	L	L	T	T	F	I	+ −	− −
71	34	2	+	S	I	0	T	T	M	L	+ +	+0
72	24	6	−	L	L	L	0	0	0	R	— +	— +
73	14	15mths	+	S	L	L	T	T	0	I	+ +	+ +
74	25	15	—	L	0	L	0	0	0	R	—0	— +
75	23	6 mths	+	0	L	I	T	T	0	L	+ +	0+
76	18	13	—	I	S	S	A	\	F	R	——	——
77	23	7	+	S	L	L	T	0	F	L	+ +	+ +
78	37	35	+	S	L	L	0	T	F	L	+ +	+ +
79	13	7	0	I	S	0	0	0	0	L	0—	—0
80	17	14	+	S	L	L	T	0	0	R	+ +	+ +
81	25	13	0	0	L	L	T	T	F	R	0—	0 −
82	21	15	0	S	0	L	0	0	0	L	00	+ +
83	31	29	+	0	?	?	?	?	?	L	+	0
84	17	2	0	S	L	0	0	0	0	R	0 +	−0
85	43	21	+	S	0	L	0	0	0	R	+0	−
86	20	18	0	0	?	?	?	?		L	0	0
87	39	1	+	S	S	L	T	0	F	R	− −	−
88	31	5	—	L	S	S	A	0	0	R	——	——
89	35	23	+	S	0	0	0	0	0	L	−0	−0
90	44	15	+	0	L	L	0	0	0	I	− −	0—
91	40	34	−	S	L	L	0	0	0	L	+ +	+ −
92	21	17	+	S	L	L	T	0	0	L	− −	+ +
93	9	2	+	S	L	L	A	A	0	L	+ +	+ +
94	19	18	0	0	L	0	T	T	0	R	0 +	00
95	13	1	+	S	L	L	T	T	0	R	+ +	+ +
96	41	26	+	0	L	L	T	T	F	R	+ +	0 +
97	18	3	+	S	L	0	0	0	0	L	+ +	+0
98	40	12	+	0	L	0	0	0	M	R	+ +	00
99	26	9	0	S	L	0	0	0	0	L	0 +	+0
101	15	2 mths	0	0	0	L	T	0	M	R	00	0+

Case No	Age	Age at onset	Ipsil vault	Ipsil middle fossa	Ipsil ventr body	Ipsil temp horn	Sept pelluc	3rd ventr	Sulci	Operation side	Correlation	
											side only	temp lobe
102	24	14	+	S	L	L	0	T	M	R	−+	−+
103	28	11	+	S	L	L	0	0	0	L	−+	++
104	40	10	+	S	0	L	0	0	F	R	+0	+−
105	26	1	+	S	L	0	T	0	0	L	+−	+0
106	35	25	+	S	L	L	0	0	F	L	++	−+
107	24	3 mths	+	S	L	L	0	0	0	R	++	+−
108	34	2	+	S	L	L	0	0	0	R	+−	++
109	27	13	0	0	0	L	0	0	0	R	00	0−
110	19	2	+	S	L	L	T	0	0	L	−+	−−
111	37	16	+	S	L	L	A	0	0	R	+−	+−
113	34	4	0	S	0	L	0	0	M	R	00	++
116	31	2	0	S	L	L	0	0	0	L	0+	++
118	45	22	0	0	S	L	T	T	0	L	0—	0+
119	20	18	+	S	L	L	0	0	0	I	++	+−
120	26	13	—	L	0	0	A	A	0	R	—0	—0
121	20	14	0	0	?	?	?	?	?	L	0	0?
122	49	37	0	S	I	0	A	A	0	R	0+	−0
123	14	12	0	S	S	L	0	0	0	R	0—	++
124	14	3	+	S	0	0	T	0	0	L	+0	+0
125	20	3	+	S	L	L	T	T	M	L	+−	++
126	34	28	+	S	0	0	0	0	0	R	−0	−0
127	25	14	0	0	L	L	0	0	0	L	0−	0−
128	35	9	+	S	S	L	T	0	0	R	+—	++

SUMMARY

In 80 % of patients with so called temporal lobe epilepsy radiologic examination suggested hypoplasia or atrophy of the ipsilateral cerebral hemisphere and/or the ipsilateral temporal lobe In about 10 % the radiologic findings were normal or ambiguous and in 10 % they suggested predominant atrophy or hypoplasia of the contralateral hemisphere and/or temporal lobe Some in this latter group were actually due to cysts or scars in the ipsilateral cerebral hemisphere producing relative smallness of the ipsilateral ventricle

ZUSAMMENFASSUNG

In 80 % der Patienten mit sog Temporallobs Epilepsie ergaben Rontgenuntersuchungen den Verdacht auf Hypoplasie oder Atrophie der ipsilateralen Hirnhalfte oder des ipsilateralen Temporallappens oder beider Teile In ca 10 % waren die Rontgenbefunde normal oder zweifelhaft in 10 % ergaben sie einen Verdacht auf Atrophie oder Hypoplasie der kontralateralen Hemisphare oder des Temporallappens oder beider Teile Einige Falle der letzten Gruppe beruhten tatsachlich auf Cysten oder Narben in der ipsilat Hirnhemisphare wodurch eine relative Verkleinerung des ipsilat Ventrikels zustandekam

RÉSUMÉ

Chez 80 % des malades atteints d épilepsie dite temporale l examen radiologique d [illegible] des signes faisant penser à une hypoplasie ou une atrophie de l hemisphère céréb al du même coté et/ou du lobe temporal du même coté Dans 10 % des cas environ les aspects radiologiques

étaient normaux ou ambigus et dans 10 % des cas ils évoquaient une atrophie ou une hypoplasie prédominant sur l hémisphère et/ou le lobe temporal controlatéral Certains cas de ce dernier groupe s expliquent en fait par des kystes ou des cicatrices de l hémisphère homolatéral qui causent une diminution relative du volume du ventricule homolatéral

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FROM THE ROENTGENDIAGNOSTIC DEPARTMENT (DIRECTOR OLLE OLSSON) AND THE DEPARTMENT OF NEUROSURGERY (DIRECTOR NILS LUNDBERG), UNIVERSITY OF LUND, SWEDEN

CEREBRAL PNEUMOGRAPHY WITH CONTINUOUS CONTROL OF VENTRICULAR FLUID PRESSURE

by

S CRONQVIST, N LUNDBERG and U PONTEN

One of us (N L) has recently introduced a technique for the continuous recording and control of the ventricular fluid pressure A thin polythene catheter is placed in one of the lateral ventricles and connected to a recording apparatus This permits tracing of the ventricular fluid pressure for long periods and also allows the introduction of gas or the drainage of fluid The technique has been applied as a routine aid in the management of cases with clinical signs of intracranial hypertension

In a study of the ventricular fluid pressure in cases of intracranial hypertension GUILLAUME & JANNY (1951) observed different forms of spontaneous fluctuations These fluctuations were classified and their clinical and pathologic significance was further developed by LUNDBERG in 1960 The most marked of these fluctuations were large plateau shaped waves which appeared suddenly without any visible cause The pressure generally rose rapidly to a level of 50 to 100 mm Hg at which it persisted for 5 to 20 minutes before falling more or less rapidly to the original value (Figs 1 and 2) The waves were often seen to correspond to fairly typical but more or less marked transient signs and symptoms, which included headache facial flush, decrease or loss of consciousness hyperpnea, nausea and vomiting as well as various motor phenomena such as convulsive movements followed by tonic rigidity of the limbs The

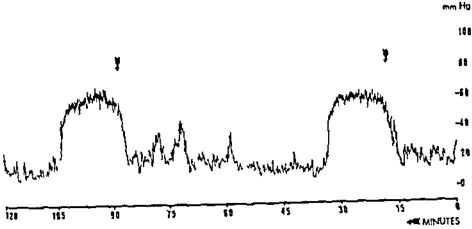


Fig 1 Increased ventricular fluid pressure in a case of central glioma Spontaneously arising plateau waves Arrows flushing and headache

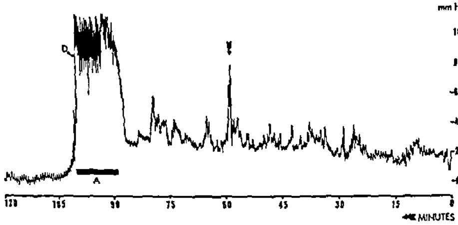


Fig 2 Increased ventricular fluid pressure in a case of metastasis of the frontal lobe Arrow = cough A = tonic rigidity respiration of Cheyne Stoke type D = drainage of fluid

observations suggested that these attacks and paroxysmal signs were identical with those previously described as cerebellar fits, tonic fits mesencephalic seizures acute incarcerations and acute herniations or coning

Abundant evidence strongly suggested a causal relationship between the plateau waves and the clinical signs and symptoms Thus these could almost regularly be relieved by the withdrawal of fluid and did not appear when the ventricular fluid pressure was kept low by continuous drainage

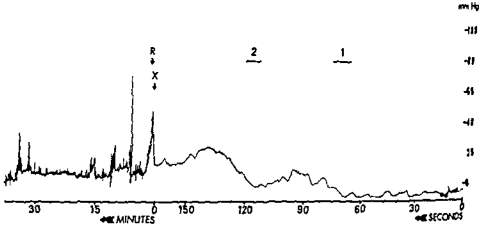


Fig 3 Lumbar encephalography normal ventricular fluid pressure in a case of calcified tumour of posterior fossa Initial and secondary rise in connection with oxygen injection 1 and 2 = injections of 5 ml oxygen ╲ = change of paper speed R = recumbent position

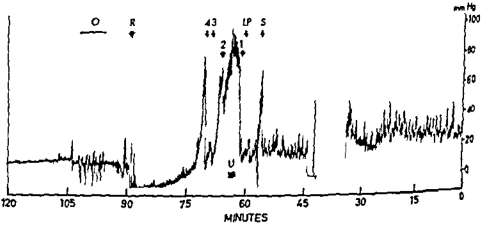


Fig 4 Lumbar encephalography increased ventricular fluid pressure in a case of cerebellar angioma 1 = injection of 5 ml oxygen Initial rise 20 to 25 mm Hg followed by a secondary rise A pressure of 55 up to more than 80 mm Hg associated with unconsciousness (U) Spontaneous decrease of pressure At the following injections (2 3 and 4) similar reactions but without unconsciousness

Ventriculography or encephalography was performed in about 100 cases with ventricular drainage by the LUNDBERG method and in 20 of these with lesions in different parts of the brain a detailed recording of the pressure variations during and after injection of oxygen was obtained The following patterns in the ventricular fluid pressure curves were often noticed

Simultaneously with the injection of oxygen there was a slight initial rise in the ventricular fluid pressure In some instances the pressure then gradually decreased again Very often, however, the initial rise was followed by a second

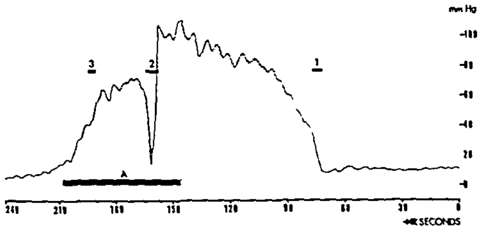


Fig 5 Ventriculography increased ventricular fluid pressure in a case of carcinomatosis of the meninges 1 = injection of 10 ml oxygen 2 and 3 = withdrawal of 12 ml and 5 ml fluid respectively

ary rise which, after a varying interval was followed by a fall in pressure The resulting curve is similar to the plateau waves that arise spontaneously Such a secondary rise could be produced even if the intracranial pressure was normal in that case, however the magnitude of the response was relatively small (Fig 3)

Only in cases with a manifest and considerable intracranial hypertension was the secondary rise considerable Clinical signs and symptoms of the type earlier described were noted during the increase in pressure It must however be pointed out that the plateau waves induced could appear without being accompanied by any clinical manifestations The pressure decreased spontaneously in some cases (Fig 4) if not or if the clinical effects were alarming, the return to the original pressure could be controlled by drainage of fluid or by administration of urea (Fig 5)

The site of the injection of the oxygen by lumbar encephalography whether into the cisterns or into the ventricles produces no difference in the appearance of the pressure variations The extent to which the secondary rise is influenced by the rapidity of injection is not quite clear There are reasons to believe that the rise is the result of a vasomotor reflex induced by the initial elevation of the pressure during the injection of oxygen There are also grounds for considering that this reflex causes widening of the cerebral arterioles followed by a decrease in the cerebral vascular resistance and a consequent increase in blood pressure within the cerebral vascular bed As a matter of fact FOG in 1934 observed widening of the pial vessels when the intraventricular fluid pressure in cats was experimentally elevated

All the signs and symptoms observed during the plateau waves could be attributed to an influence on the brain stem but how these are finally induced

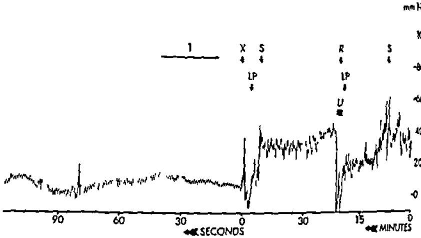


Fig 6 Lumbar encephalography increased ventricular fluid pressure in a case of stenosis of the aqueduct LP = lumbar puncture no escape of liquor decrease in ventricular fluid pressure U = unconsciosusness R = recumbent position S = sitting position

is not obvious A prominent role is played by herniation of brain tissue through the tentorial notch or the foramen magnum It is, however, worth mentioning that in 3 cases of diffuse carcinomatosis, all with increased intracranial pressure and without signs of herniations on encephalography or angiography, the variations in the pressure described were noted The cases also presented the typical clinical manifestations associated with the appearance of plateau waves

Unconsciousness during pneumography is encountered not only in cases with increasing ventricular fluid pressure but also sometimes when this pressure remains low As there is a marked fall in blood pressure and the patient is pulseless this is most probably a vaso vagal syncope This kind of attack can occur as soon as the subject is put in a sitting position or when the lumbar puncture is made (Fig 6) These patients are pale and sweating, while those who are unconscious due to increased ventricular fluid pressure often have flushing of the face and a well defined pulse in addition to the signs described

Conclusions

This investigation has shown that injection of gas into the ventricular system produces variations in the intraventricular pressure In cases with a high initial ventricular fluid pressure these variations may be marked and of a type similar to those that may arise spontaneously in cases of intracranial hypertension The variations may be accompanied by manifestations that indicate a severe influence on the brain The tracings also suggest that unconsciousness during pneumography is sometimes of another type and is the equivalent of fainting

The technique introduced by LUNDBERG has several roentgenologic advantages

1 By continuous control during pneumography it is possible to master the complications that may arise as a consequence of acutely increased intracranial pressure This is valid both for ventriculography and encephalography

2 The use of an indwelling catheter makes it possible to refill the ventricle during the examination without further ventricular puncture

3 The catheter also makes it possible to obtain satisfactory filling of the third and fourth ventricles by the injection of gas during the exposure, with the head in a suitable position

To these advantages may be added one of special importance to the surgeon The technique makes it possible to control the ventricular fluid pressure after pneumography and immediate operation following the roentgen examination is unnecessary

SUMMARY

A technique for the application of continuous recording and control of the ventricular fluid pressure as a routine aid in the treatment of intracranial lesions is described It was found that the introduction of gas may produce rapid elevations in the ventricular fluid pressure The controlled reduction of the pressure during and after pneumography makes the procedure safer and immediate surgery unnecessary

ZUSAMMENFASSUNG

Eine Technik fur die Anwendung fortlaufender Messung und Kontrolle des Druckes der Ventrikelflussigkeit als eine Rutinmethode bei der Behandlung intrakranieller Erkrankungen wird beschrieben Man fand dass die Einfuhrung von Gas einen rapiden Anstieg dieses Druckes hervorrufen kann Die kontrollierte Herabsetzung des Druckes wahrend und nach einer Pneumographie macht diese Prozedur sicherer und einen unmittelbaren chirurgischen Eingriff unnotig

RÉSUMÉ

Les auteurs décrivent une technique utilisant un enregistrement et une régulation continus de la pression liquidienne intraventriculaire comme moyen adjuvant habituel dans le traitement des lésions intracraniennes Ils ont constaté que l introduction de gaz peut causer une élévation rapide de la pression liquidienne intraventriculaire La possibilité de réduire la pression pendant et après la pneumographie rend cet examen moins dangereux et rend inutile l intervention chirurgicale immédiate

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FROM THE DEPARTMENTS OF RADIOLOGY (DIRECTOR PROF T DALE) AND NEUROSURGERY (ACTING DIRECTOR TORMOD HAUGE), RIKSHOSPITALET, OSLO, NORWAY

UREA AS AN AID IN ENCEPHALOGRAPHY

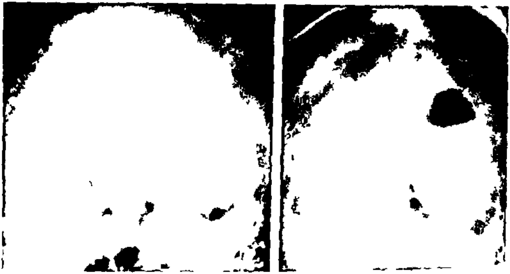
by

ARNE ENGESET and TORMOD HAUGE

Neurosurgical investigations of the intravenous infusion of urea have shown that increased intracranial pressure may be reduced to zero (JEPPSSON & JARPE 1960) and thereby lead to improvement of the patient s condition and in the conditions for operation We have made similar experiences in our department in a material of twenty six supratentorial and infratentorial expanding lesions in which this method was employed at operation We thus have found that in cases of intracranial hypertension encephalography after infusion of urea may be more easily carried out and that complications and discomfort to the patient are then reduced In view of these satisfactory results we feel justified in assuming that the following case reports may be of interest

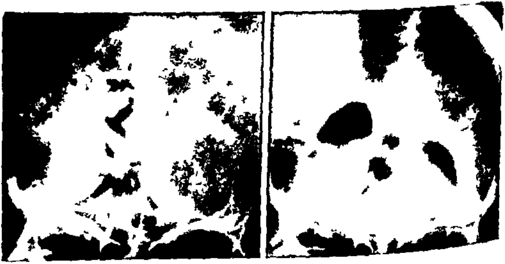
Case reports

Case I Male aged 44 with signs of a tumor of the right posterior fossa no papilloedema The injection of 26 ml air *at encephalography in another hospital failed to fill the posterior* fossa sufficiently and the examination was followed by collapse The patient was referred to us and encephalography was repeated with 30 ml air We failed to fill the ventricular system completely (Fig 1a) and again the patient collapsed Three days later the patient was given 1 5 g/kg bodyweight urea intravenously and one and a half hours later was subjected to encephalography The condition of the patient was now excellent and 25 ml air was injected without difficulty The ventricular system was well filled and an expanding lesion on the right side displacing the fourth ventricle backwards to the left was disclosed (Fig 1b) The findings were correlated with the clinical examination and a diagnosis of glioma of the pons was established The patient was not operated upon The patient suffered no apparent discomfort on the day of the examination nor on the following days



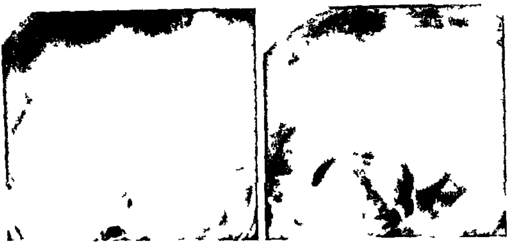
a b

Fig 1 Case 1 a) Second attempt at encephalography Insufficient air filling of the ventricular system b) *Third* attempt at encephalography after urea infusion Satisfactory air filling of the fourth ventricle *disclosing* an expanding lesion on the right side



a b

Fig 2 Case 3 a) First attempt at encephalography with 40 ml air No filling of the ventricular system Extracerebral filling with the pericallosal cistern tilted to the right b) Third attempt at encephalography after urea infusion Excellent air filling with displacement of the ventricles by an expanding lesion in the left hemisphere



a b

Fig 3 Case 4 a) Encephalography with urea infusion and 17 ml air Signs of an expanding lesion in the right cerebellopontine angle b) Same encephalography with 42 ml air The expanding lesion is better shown (The patient experienced no discomfort)

Case 2 Girl aged 16 years with signs of a left side cerebellar tumour papilloedema of 3 dioptres Encephalography with 20 ml air was accompanied by nausea and vomiting The encephalograms revealed herniation of the tonsil and the intracranial air filling was insufficient Three days later the same procedure was carried out and now with urea infusion The patient suffered no discomfort but there was no air filling of the ventricular system and only the tonsil was mapped out as before Ventriculography was performed some days later and an expanding lesion of the left cerebellar hemisphere displacing the fourth ventricle dorsally was disclosed

A glioma of the left hemisphere was revealed at operation The postoperative course was uneventful

The failure of this examination in spite of urea infusion remained unexplained

Case 3 Woman aged 44 with evidence of an expanding lesion of the left hemisphere no papilloedema Encephalography with 40 ml air was performed but no filling of the ventricular system was obtained The pericallosal cistern was tilted to the right (Fig 2a)

The clinical signs increased during the following eight days and a second encephalography was attempted with 20 ml air The patient vomited during the procedure and no air filling was obtained Seven days later a third encephalography thus time with urea infusion produced excellent air filling and disclosed an expanding lesion in the parietal region of the left hemisphere (Fig 2b)

The tumour was confirmed at operation and found to be a large cystic glioma The postoperative course was uneventful

Case 4 Boy aged 15 years with signs of a tumour in the right cerebellopontine angle slight papilloedema Encephalography after urea infusion outlined a tumour in the right cerebellopontine angle The tumour could be demonstrated with 17 ml air (Fig 3a) but was better outlined with 42 ml air (Fig 3b) An acoustic neurinoma was radically extirpated the facial nerve being preserved

SUMMARY

The value of the intravenous infusion of urea in lowering the intracranial pressure in encephalography is discussed and illustrated by four cases which were selected from a material of 21 cases

ZUSAMMENFASSUNG

Der Wert der intravenosen Verabreichung von Harnstoff (Urea) zur Druckverminderung im Schadel bei Enzephalographie wird besprochen an Hand von vier Fallen die aus einem Gesamtmaterial von 21 Fallen ausgewahlt wurden

RÉSUMÉ

Les auteurs étudient l intéret de la perfusion intraveineuse d ureé pour abaisser la pression intracranienne au cours de l encéphalographie ils en donnent en exemple quatre cas sur une série de 21 cas

REFERENCES

JEPPSSON S and JARPE S Intravenous urea as an aid in intracranial surgery A clinical report Acta chir scandinav 120 (1960) 137

Comments on

'Urea as an aid in encephalography'

by

Tormod Hauge Oslo

The urea method has been employed during the last five months in ?? encephalographies only two of which called for ventriculography, one with fatal result Nausea and vomiting have been observed to occur after the infusion of urea but these symptoms are considerably outweighed by the advantages of the method Among fifty cases, in twenty nine of which urea infusion was used as an aid in intracranial surgery, we have observed three cases of thrombophlebitis at the site of the infusion but these were all cured by conservative treatment, as described by JEPPSSON & JARPE

To prevent possible complications following air filling of the ventricular system when the urea effect of the ventricular pressure subsides operation is performed as soon as the roentgenologic diagnosis has been established

Tentorial pressure cone signs arose in one case only, after an excellent a.. filling of the ventricular system had disclosed a huge expanding lesion in the left temporo occipital region The extirpation of the gliomatous tumour i this case was accompanied by extensive venous haemorrhage which was more troublesome to overcome than usual The postoperative course however was uneventful and the result satisfactory

We have had no fatal cases in our series It would appear to the writers that one single urea infusion is sufficient for the roentgenologic examination as well as for the subsequent operation

FROM THE CHILDREN'S HOSPITAL, SHEFFIELD ENGLAND

DEVELOPMENT OF VENTRICULAR DIVERTICULA FOLLOWING VENTRICULAR PUNCTURE IN HYDROCEPHALIC INFANTS

by

R G GRAINGER and J LORBER

This paper reports a little known complication of the puncture of the lateral cerebral ventricles in children with increased intracranial pressure or with hydrocephalus This is the formation of a diverticulum or cavity, extending from the lateral cerebral ventricle at the site of a previous ventricular puncture

The standard works of reference on pneumo ventriculography make no mention of this complication LORBER (1951) reported three cases of diverticulum of the lateral ventricle after intra ventricular injections of streptomycin in the treatment of tuberculous meningitis with obstructive hydrocephalus

In a monograph on infantile hydrocephalus (1949) DOROTHY RUSSELL briefly noted that rupture of the ventricular wall may cause a false diverticulum extending into the cerebral white matter DEKABAN (1958) reported a child of fourteen months in whom an encephalogram revealed elongated cavities extending from the lateral cerebral ventricles to the surface of the brain along the pathway of bilateral ventricular punctures performed for ventriculography seven months previously He posed the question is needling of the brain entirely harmless? Our experience indicates that in the group of patients reported here, needling of the cerebral ventricles is certainly not harmless

SUMMARY

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a b

Fig 2 Same case as in fig 1 Repeat ventriculography at 34 weeks a p (a) and lateral (b) projections Ventricular pressure = 100 mm grade 1 hydrocephalus The cavity resulting from the first puncture now measures 2[illegible] × [illegible]2 × 22 mm

technical difficulty was encountered not even in locating normal sized lateral ventricles The intraventricular cerebrospinal fluid pressure was recorded by manometer, 20 to 40 ml of sterile air were injected into the ventricle and a greater volume of cerebrospinal fluid allowed to escape The needle was in the ventricle for an average of five minutes Following removal of the needle, standard ventriculographic projections were used always including erect a p and lateral films

The children were not given local or general anaesthetic but were pacified by sucking a sweetened dummy and were usually quiet during the procedure

Results

The ventriculograms of 223 children were reviewed with particular reference to the presence of air in the track of the needle or at the site of a previous puncture

1 Ventriculography without preceding ventricular puncture In 212 cases there had been no previous ventricular tap and of these 20 (9 %) presented air along the track of the needle introduced for the ventriculography The appearance of the air filled needle track was characteristic and diagnostic The track was directed from the lateral angle of the roof of the lateral ventricle upwards and outwards in the coronal plane towards the lateral angle of the anterior fontanelle There was no doubt that this was indeed the pathway of the puncture needle The shape of these air filled tracks was also characteristic and constant They were of an elongated triangular shape with the narrow base in contact with the roof of the lateral ventricle and the apex directed towards the calva



Fig 1 Case of lumbo-sacral meningomyelocoele 10 10 cm Ventriculography at 2 weeks Ventricular c.s.f pressure = 230 mm grade I hydrocephalus Airfilled needle track 5 × 5 × 17 mm

Case material A large clinic has been established in our hospital for the investigation and treatment of infants with (congenital or acquired) hydrocephalus or with meningomyelocoele or encephalocoele

This review covers a period of two years (1959 and 1960) during which 223 infants under one year of age underwent ventriculography All were suspected of having hydrocephalus either because they had a meningomyelocoele or encephalocoele or because their head was enlarging at an abnormal rapid rate, as demonstrated on head circumference charts The clinical diagnosis in theses cases are presented in a Table, p 573

The degree of hydrocephalus was assessed as previously described (Lorber 1961) Ventriculography revealed 35 cases without hydrocephalus 6 cases of trivial (grade I) hydrocephalus 102 cases of considerable ventricular dilatation (grade II), and the remaining 80 cases displayed such a gross degree of ventricular dilatation that only a few millimetres of cerebral tissue remained (grade III) In the considerable majority of these cases the intraventricular cerebrospinal fluid pressure was increased

Technique of ventricular puncture The puncture was performed in the usual manner, through the lateral angle of the open anterior fontanelle A standard infant lumbar puncture needle (B W G 20 or 21) was inserted in the coronal plane, downwards and inwards to meet the roof of the lateral ventricle A



Fig 4 Case of lumbar meningomyelocoele excised *E coli* meningitis Many intraventricular injections of antibiotics and hydrocortisone Ventriculography at 5 weeks Ventricular c.s f pressure = 200 mm grade I hydrocephalus Bilateral symmetrical cavities due to punctures each measuring 20 × 20 × 25 mm

At ventriculography two weeks after the first examination the cerebral cavities had probably not reached their final shape, and they took the form of elongated lobulated and rounded pyramids

In four of these 8 cases, the first ventriculographic examination had not revealed air in the needle track but the subsequent cavity had obviously resulted from the earlier puncture The cavities in these four cases differed in no way from those found in the four cases in which an air filled needle track had been demonstrated at the first ventricular puncture

Table

The clinical diagnoses in a material of 223 cases examined by ventriculography during a period of two years in 1959—1960

A Hydrocephalus without meningomyelocoele or encephalocoele	
Simple congenital hydrocephalus	38
Post meningitic hydrocephalus	5
Hydrocephalus of miscellaneous aetiologic origin	3
Total	46
B Meningomyelocoele	
No hydrocephalus (no meningitis 30 with meningitis one)	31
With hydrocephalus (no meningitis 133 with meningitis 9)	142
Total	173
C Normal cases	
Hydrocephalus suspected	4
Grand total	223



a b

Fig 5 Case of small sacral meningocoele excised *E coli* meningitis Fourteen intraventricular injections of antibiotics and hydrocortisone had been made into each lateral ventricle a) Ventriculography at 4 weeks Right post traumatic cavity measuring 20 × 20 × 22 mm Left cavity measuring 10 × 10 × 16 mm b) Autopsy section of brain a few days after the ventriculographic examination

3 Ventriculography after multiple ventricular punctures In this series of 223 cases there were 15 cases of earlier meningitis As may be seen from the Table, p 573, the infection in ten cases was a complication of a meningomyelocoele or encephalocoele, in which the covering membrane had broken down before or after surgical repair In the remaining five cases there was no congenital abnormality but a neonatal meningitis, and obstructive hydrocephalus developed because of tentorial adhesions Multiple ventricular punctures were indicated in several of these cases for the injection of antibiotics and hydrocortisone In five of the cases, ventriculography which was performed after multiple ventricular taps, revealed large cerebral cavities resulting from these punctures. The cavities differed in shape from those seen after a single preceding ventricular puncture as described under (2) above

The cerebral cavities seen following multiple ventricular taps tended to be irregular in outline, and loculated and lobulated in shape Probably the lobulations were due to damage caused at separate punctures These cavities tended to be larger than those found after a single puncture, and in one case they protruded beyond the margins of the anterior fontanelle (Fig 3) As the multiple punctures were usually bilateral cavities were found communicating with both lateral ventricles The bilateral cavities were usually symmetrical in size and shape

These cavities, similar to the cavities described in the previous section communicated freely with the lateral cerebral ventricles and did not contain any filling defects The largest cavities were found in the cases in which the ventricles were not grossly enlarged for there is inadequate room in the thin cerebral covering of grade III hydrocephalus to develop an appreciable cavity

Examples of cerebral cavities, which occurred after multiple ventricular punctures are illustrated in Figs 3 4 and 5

Discussion

The pathogenesis of the cavities which may occur after ventricular puncture is not yet established It would seem that a clean puncture wound of the ependymal lining of the lateral ventricle of children with increased intra cranial pressure permits cerebrospinal fluid to escape into the surrounding white matter The brain of the infant is not fully myelinated and is probably less resistant to liquefaction than the brain of an adult The needle track may be demonstrated by air introduced at the time of the first puncture This narrow triangular track may gradually enlarge and within a few weeks its base will become a large defect in the roof of the lateral ventricle The cavity so formed becomes hemispherical in shape After multiple ventricular taps, the cerebral cavities which may develop are lobulated and loculated, presumably as a result of the repeated trauma We do not know whether these cavities may occur in children with normal cerebrospinal fluid pressure and dynamics

We have as yet inadequate pathological data concerning the walls of these cavities but in the few autopsy specimens which we have examined there has been no evidence of haemorrhage, and the walls have consisted of glial tissue

The formation of these post puncture cavities is not invariable, even in infants with increased intracranial pressure They were not observed in infants with extreme dilatation of the lateral ventricles for in these merely a few millilitres of cerebral tissue covered the ventricles We have encountered occasional cases in which no cerebral cavitation developed even after several punctures of ventricles which were not grossly dilated We estimate, however, that in perhaps 75 % of children in our series cerebral cavitation will develop We hope shortly to publish a more comprehensive review of our case material which may provide a more accurate estimate

The clinical significance of these post traumatic excavations of brain is not yet known Many of these infants have preceding cerebral impairment by virtue of their hydrocephalus and other congenital malformations Further cerebral deficit would be difficult to confirm The cavitation occurs in a relatively silent area of the brain In one case a child of 2 years of age the physical and mental development so far appears normal despite large bilateral cavities measuring 30 × 30 × 20 mm (see Fig 3) It would not, however be surprising if the considerable cerebral damage which we have observed were to cause clinical evidence of cerebral deficit

Conclusion

The damage produced by needling the brain haemorrhage calcification and the cavitation now described must be reduced to a minimum Cerebral needling for diagnostic or therapeutic purposes should only be undertaken



a

Fig 5 Case of small sacral meningocoele exci tions of antibiotics and hydrocortisone had been i at 4 weeks Right post traumatic cavity measu 10 × 16 mm b) Autopsy section of brain a fe

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SERVICE DE NEUROCHIRURGIE, CENTRE HOSPITALIER ET UNIVERSITAIRE MONTPELLIER FRANCE

L'EXPLORATION DE LA FOSSE POSTERIEURE ET DE LA JONCTION CRANIO-ENCEPHALIQUE PAR MOYENS DE CONTRASTE

par

C GROS A ROUGEN et B VLAHOVITCH

Sans renoncer aux investigations usuelles par contraste gazeux nous utilisons volontiers dans de nombreuses affections de la fosse posterieure un produit de contraste positif, soit comme complement soit seul Les modifications morphologiques se revelent avec une nettete non egalisee il existe beaucoup moin de superpositions d images etant donne que le cheminement de la bille lipiodolee moule successivement les differentes structures

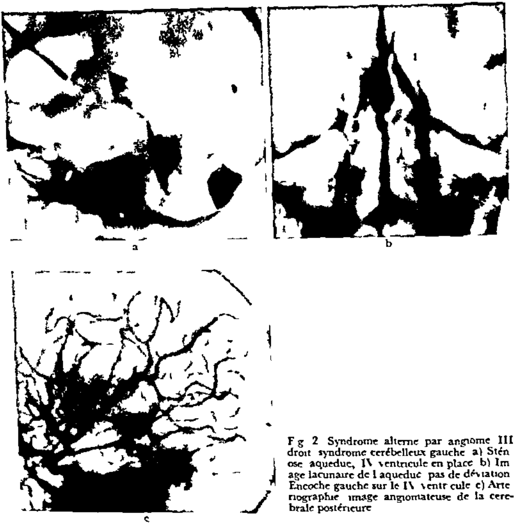
D autre part l exploration lipiodolee necessite des manœuvres moins ardues et compliquées qu une etude gazeuse

Dans certains cas cependant l exploration jumelee lipiodol-contraste gazeux reste indispensable pour approcher un diagnostic correct

Il ne nous parait pas utile de presenter en premier lieu l aspect ventriculographique tel qu il se degage de nos ventriculogrammes normaux Un certain nombre de reperes bien etablis actuellement facilitent la lecture et l interpretation des images anormales

Les stenoses de l aqueduc de Sylvius L emploi d un produit de contraste positif lourd facilite singulierement l etude de la morphologie de l aqueduc ainsi que des formations ventriculaires adjacentes





a b c

Fig 2 Syndrome alterne par angiome III droit syndrome cerébelleux gauche a) Sténose aqueduc, IV ventricule en place b) Image lacunaire de l aqueduc pas de déviation Encoche gauche sur le IV ventricule c) Arteriographie image angiomateuse de la cerebrale postérieure

Les stenoses completes L interpretation pathogenique des données radiologiques dans ces cas reste difficile Il est évident que la stenose complete ne peut etre affirmee que si les cliches de controle tardifs (y compris le cliché lombaire) confirment l obstacle absolu Il nous semble hasardeux quant a l interpretation de limiter les explorations au seul transit lipiodole

L emploi successif dans les memes conditions radiologiques d un contraste positif intraventriculaire et d un contraste gazeux (encephalographie fractionnee) permet une évaluation meilleure de la morphologie des structures interessees (citernes de la base pedonculaire et prepontique citernes vermienne et quadrijumelle) L applatissement de ces citernes est en faveur d un processus neoformatif



Fig 3 Stenose par toxoplasmose



a



b



c

Fig 4 Granulome aqueduc bulbulaire a) et b) Image en entonnoir de l aqueduc (profil et face) c) Blocage inferieur du IV ventricule



Fig 5 Malformation d Arnold Chiari IV ventricule laminé et étiré obex en position sous-foraminale

L image en entonnoir regulier ou la dilatation ampoulaire de la portion initiale de l'aqueduc, sans deviation, ni empreinte, signe classiquement la stenose non tumorale, par atrésie

Chez le nouveau ne et le nourrisson ceci est certainement vrai dans la majorite des cas Encore que chez lui la pathologie infectieuse ou parasitaire joue un certain role (Fig 3)

Chez l adulte et l adolescent, le probleme se complique du fait de la fréquence des neoformations infiltrantes ou expansives Chez eux le transit lipiodole doit etre complété par l etude gazeuse des citernes

Cependant, l iodoventriculographie peut fournir des renseignements precieux C etait ainsi que chez une malade ou la symptomatologie clinique se reduisait aux seuls signes d hypertension intracranienne L aspect de la sténose était celui d un entonnoir tres allonge il est vrai L obstacle se trouvait a la fin de l aqueduc, a son abouchement dans le 4° ventricule Or chez elle nous avons ete frappés par l ecartement considerable du recessus sus epiphysaire Il s agissait d un *épendymome envahissant le tectum*

Nous pensons que la bascule du recessus sus epiphysaire est un signe de valeur en faveur d une neoformation

Qu il y ait ou non dilatation ampoulaire, ou une image en entonnoir, un obstacle situe sur le segment de transition entre aqueduc et quatrieme ventricule (donc au delà de 10 mm du depart aqueductal) doit évoquer la nature neoformative de la stenose (Fig 4)

La malformation d'Arnold Chiari La ventriculographie avec contraste positif fournit dans cette affection des clichés particulierement demonstratifs Sans



Fig 6 Fibrose du foramen de Magendie face et profil

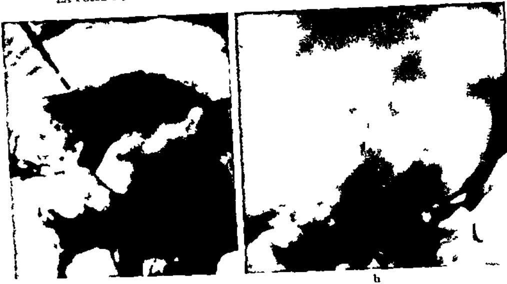
insister, car les images (Fig 5) sont plus eloquentes que toute parole, disons q les ventriculogrammes sont un reflet fidele de la situation basse du rhomence phale avec quatrieme ventricule lamine et etire, obex en position sous-for aminales

La fibrose du foramen de Magendie L interet de ce paragraphe est surtout iconographique car l aspect radiologique (du moins pneumoencéphalograph que) est bien connu (Fig 6 et Fig 7) Dans le cas represente par Fig 7 il s agit

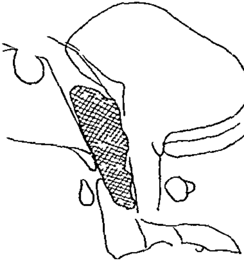


a b

Fig 7 Hydrocéphalie triventriculaire majeure revélée par traumatisme a Trans l prod d press b) Cinq semaines plus tard blocage du trou de Magendie



a b



c

Fig 8 Méningiome du clivus a) Grande citerne prépontique avec hydrocéphalie b) Refoulement postérieur de l'aqueduc. c) Schéma anatomique

très certainement d'une fibrose réactionnelle au lipiodol (Une première exploration lipiodolée avait révélé une énorme hydrocéphalie avec cependant, des voies d'écoulement libres.)

Les masses extraparenchymateuses juxta axiales L'étude des cisternogrammes en cas de tumeur de l'angle permet de faire deux constatations intéressantes ces masses obstruent exceptionnellement la citerne prépontique (pour laquelle un bon remplissage est pratiquement la règle) dans beaucoup de cas cette



a



b



c

Fig 9 Large empreinte pseudo-tumorale a) Profil image des amygdales da s la grande citerne cérébelleuse b) Face image correspondante (Coulée intra mygdalienne) c) Craniopharyngiome Large empreinte pseudotumorale (empreinte pl xulaire)

meme citerne présente au contraire des dimensions particulierement grandes

La profondeur de la citerne prépontique telle qu elle se dégage de nos cisternogrammes normaux, varie entre 6 et 10 mm dans son segment superieur et de 3—6 mm pour son segment inferieur médiopontique

Les tumeurs du tronc cerébral peuvent soit l aplatir soit respecter ses

dimensions normales Elles ne l agrandissent jamais Les masses qui occupent le compartiment postérieur de la fosse cerebelleuse l aplatissent regulierement

On admet que les tumeurs de l angle qui nous interessent plus specialement ici se comportent sous cet aspect comme les tumeurs du tronc cerebral

Or comme nous venons de le preciser les tumeurs de l angle ont tendance, non seulement de respecter les dimensions de cette citerne, mais de l agrandir Nous ajouterons que ceci semble particulier aux masses soit nettement centrees par le paquet acoustico-facial soit a développement asymmetrique a extension antero posterieure Les masses a extension postero-inferieure predominante peuvent l aplatir

Il s agit d une ouverture vraie de la citerne et non d une simple superposition des secteurs medians et des prolongements latéraux Les cisternotomographies font nettement ressortir ce fait Les controles postoperatoires montrent le retour de ces grandes citernes à des dimensions moyennes nettement inferieures aux mensurations pre operatoires

Les memes images de grande citerne sont retrouvees dans les masses extra parenchymateuses prebulbaires dans la mesure ou leur extension ne comble pas les espaces sous arachnoidiens (Fig 8)

Il est evident que ces modifications particulieres de la citerne prépontique ne constituent qu un appoint secondaire dans les cas ou des signes plus directs ont pu etre mis en evidence Elles gardent leur signification dans les cas litigieux Tout d abord la présence d une grande citerne ne saurait en aucun cas exclure la possibilite d une néoformation de la fosse posterieure Elle permet tout au plus d eliminer le groupe tumoral du compartiment posterieur

D autre part sa valeur nous semble certaine dans la differentiation entre masses du tronc cerebral et tumeurs extra parenchymateuses

Dans ces conditions une grande citerne devra orienter vers une masse extra parenchymateuse

Les fausses empreintes L emploi presque systematique de la ventriculographie lipiodolée pour l exploration de la fosse posterieure nous a fait connaitre le piege de certaines fausses empreintes tumorales, notamment de la partie inferieure du 4 ventricule (empreintes plexulaires et amygdaliennes)

Ces images méritent d etre signalees La determination de la situation du 4 ventricule ainsi que celle de l obex eviteront la meprise

Nous pensons que ces images traduisent l empreinte des amygdales dans les cas ou une grande citerne cerebelleuse et la position du malade permettent l accumulation du lipiodol dans le lac sous arachnoidien posterieure (Fig 9)

RESUMÉ

Les auteurs decrivent des images radiologiques anormales de la fosse postérieure qui sont moins souvent decrites que celles qui sont dues à des tumeurs volumineuses En ce qui concerne les modifications de calibre de l aqueduc de Sylvius ils décrivent des signes radiologiques



a



b



c

Fig 9 Large empreinte pseudo-tumoral a) Profil image des amygdales dans la grande citerne cerébelleuse b) Face image correspondante (Coulée intra mygdalienne) c) Craniopharyngiome Large empreinte pseudotumorale (empreinte plexulaire)

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SERVICE DE RADIOLOGIE (PROF S KADRNKA) DE L INSTITUT DE RECHERCHES OTO-RHINO-LARYNGOLOGIQUES (PROF A SERCER) DE L HOPITAL GENERAL STOJANOVIC, ZAGREB YOUGOSLAVIE

TECHNIQUE DE L'ENCEPHALOSTRATIGRAPHIE GAZEUSE

par

SILVIJE KADRNKA

Le systeme des ventricules et des citernes du cerveau se prete a une exploration stratigraphique de face et de profil au meme titre que l encephalographie classique notre technique personnelle etant comme suit

I Coupe sagittale mediane malade en position assise

Le malade est assis sur un tabouret devant la grille du craniotome de Barazzetti On peut aussi utiliser une table basculante universelle Le corps du malade est penche en avant La tete est appuyee contre la grille par la region temporale

Ier temps tête en flexion forcee a 45° environ Apres ponction lombaire et echange fractionne de 15 a 20 ml de gaz et de liquide cephalo-rachidien suivant les principes techniques actuellement en cours on procede a la prise de la premiere coupe sagittale mediane Elle montre la grande citerne cerebello-medullaire la citerne de la grande veine de Galien la citerne vermienne avec sa subdivision en sillon prelingual, sillon precentral sillon postcentral sillon post-culmen sillon post declive grand sillon circonferentiel sillon post pyramidal sillon prepyramidal et sillon post nodulaire



Fig 1 Position assise du malade region temporale contre la grille du craniotome

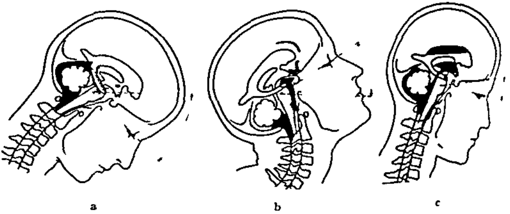
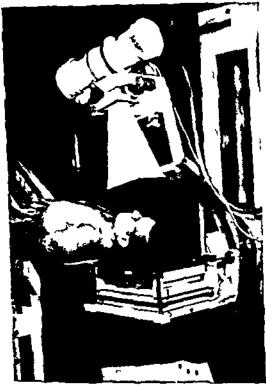
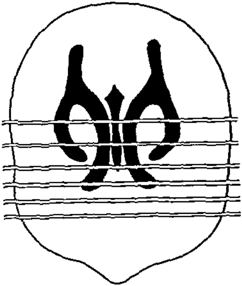


Fig 2 a) Ier temps tête en flexion forcée injection fractionnée de 15 à 25 ml d air b) 2 temps tête en déflexion maxima réinjection de 10 à 25 ml d air c) 3 temps tête en flexion moyenne

2e temps tete en extension maxima Apres une nouvelle injection de 10 à 15 ml d air, on prend la deuxieme coupe sagittale mediane Elle montre la citerne prépontique, la citerne interpédonculaire, la citerne chiasmatique la citerne de la lame terminale, le sillon du corps calleux la scissure calloso-marginale et quelques autres sillons interhemisphériques



a



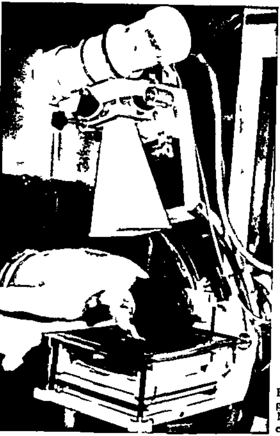
b

Fig 3 a) Malade en decubitus dorsal occiput sur la grille b) Plans de coupe frontaux à 1 5 cm 3 cm 4 cm 5 cm et 6 cm en avant du conduit aud tif externe

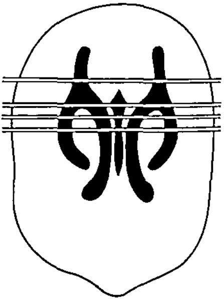
3e temps tete en flexion moyenne Cette troisieme coupe montre de plus le III et le IV ventricule ou seulement ces cavites si l examen a éte commencé avec la tete en flexion moyenne

II Malade en position couchee

I temps coupes frontales decubitus dorsal Les coupes frontales sont faites parallelement au plan frontal bi auriculaire qui passe par les conduits auditifs externes et est perpendiculaire au plan sagittal et au plan horizontal de Frankfurt Les plans de coupe sont situes a 1 5 cm 3 cm 4 cm 5 cm et 6 cm en avant du conduit auditif externe Elles montrent a 6 cm la scissure interhémis pherique , a 5 cm la scissure calloso marginale et le sillon du corps calleux a 4 cm la citerne chiasmatique la citerne de la lame terminale et le pole des cornes frontales a 3 5 cm la partie sphenoidale des scissures de Sylvius et la partie antérieure du troisieme ventricule a 3 cm la citerne interpedonculaire a 1 5 cm les corps des ventricules lateraux et les cornes temporales le troisieme ventricule et les citernes ponto cérebelleuses



a



b

Fig 4 a) Malade en procubitus, front sur la grille b) Plans de coupe frontaux à 0,75 cm, 1 5 cm et 3 cm en arrière du conduit auditif externe

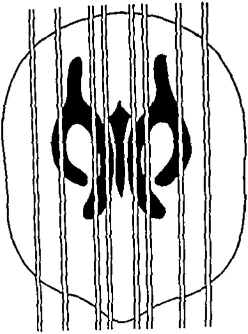
2e temps coupes frontales en procubitus Un plan de coupe passe par les conduits auditifs externes et les autres a trois quarts de centimetre, à 1,5 cm à 3 cm et a 4 cm en arriere du conduit auditif externe Sur la coupe passant par les conduits auditifs externes on voit les carrefours la citerne de la grande veine de Galien et les citernes circumpédonculaires A 1 5 cm, on a les carrefours, la citerne supra cerebelleuse et le quatrieme ventricule A 4 cm on a la citerne supra cérebelleuse et les cornes occipitales

3e temps coupes sagittales, tete en appui temporal La coupe sagittale sert de plan de réference La position de la tete correspond au profil des techniques radiographiques standard C est en partant de ce plan zéro que nous procédons aux autres coupes sagittales, en progressant de part et d autre vers le plan d appui superficiel temporo auriculaire

On met en évidence à trois quarts de centimetre du plan médian la corne frontale et le corps du ventricule latéral, la citerne rétro-pulvinarienne la citerne chiasmatique, la citerne de la lame terminale et la scissure call[illegible]



a



b

Fig 5 a) Malade couche region temporale contre la grille b) Plans de coupe sagittaux à 0 75 cm 1 5 cm 3 cm et 5 cm de part et d autre du plan médian

marginale a 1 5 cm du plan median le pole de la corne frontale le carrefour et la citerne circumpedonculaire a 3 5 cm du plan median la corne temporale et la partie externe de la scissure de Sylvius , celle ci est seule visible a 5 cm du plan median

Discussion

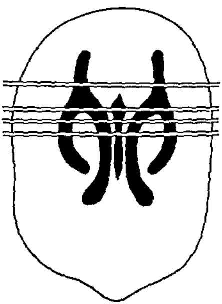
L examen encephalostratigraphique peut se faire de deux manieres Dans un premier procéde on prend une serie de coupes a des profondeurs appro priees de maniere que soient representees toutes les parties essentielles des ventricules et des citernes

Le second procéde consiste a prendre un nombre limite de coupes a des profondeurs selectionnees mettant en evidence quelques uns seulement des secteurs liquidiens

Le programme minimum qui doit entrer dans le cadre de tout examen moderne d encephalocisternographie gazeuse comporte deux ou trois coupes obligatoires une sagittale mediane et deux frontales l une rétro auriculaire et l autre pre auriculaire



a



b

Fig 4 a) Malade en procubitus front sur la grille b) Plans de coupe frontaux à 0,75 cm, 1 5 cm et 3 cm en arrière du conduit auditif externe

2ᵉ temps coupes frontales en procubitus Un plan de coupe passe par les conduits auditifs externes et les autres a trois quarts de centimètre, a 1,5 cm, à 3 cm et a 4 *cm* en arriere du conduit auditif externe Sur la coupe passant par les conduits auditifs externes on voit les carrefours, la citerne de la grande veine de Galien et les citernes circumpedonculaires A 1 5 cm, on a les carrefours la citerne supra cérebelleuse et le quatrieme ventricule A 4 cm on a la citerne supra cerébelleuse et les cornes occipitales

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On met en evidence à trois quarts de centimetre du plan médian la corne frontale et le corps du ventricule latéral la citerne rétro-pulvinarienne la citerne chiasmatique, la citerne de la lame terminale et la scissure cal...

appearances of the aqueduct and fourth ventricle may however be so small as to be overlooked This may also happen when a positive contrast medium is used, a procedure that would appear to give no more information concerning the aqueduct and the fourth ventricle than air There may be no changes present and it is then not possible to demonstrate the presence of an expansive process by ventriculography Expansive processes in the posterior cranial fossa may however produce alterations in the subarachnoid cisterns even in the absence of ventricular changes and thus be demonstrable only with lumbar encephalography Some of these changes, such as flattening of the pontine cistern and herniation of the cerebellar tonsils through the foramen magnum (DAVIDOFF & EPSTEIN 1950, LINDGREN 1950, ROBERTSON 1957, RUGGIERO 1957) are already well known

SCHECHTER BULL & CAREY (1958), as well as ROTH (1961), have recently described changes in the subarachnoid cisterns above the tentorial notch in cases of occlusive hydrocephalus and infratentorial expanding lesions We have also observed these changes in a great many cases of infratentorial tumors and their appearances in connection with pontine angle tumors were reported in a previous publication (LILIEQUIST 1959) The changes in the supratentorial cisterns consist of a widening of the cisterna veli interpositi, the ambient wing cisterns and the cisterna corporis callosi

Widening of these cisterns together with flattening of the pontine cistern and herniation of the cerebellar tonsils always indicate an expansive process of the posterior cranial fossa The widening of the supratentorial cisterns however occurs with tumors located in the vermis and the cerebellar hemispheres as well as with tumors in the posterior part of the posterior cranial fossa and does not indicate the site of the tumor as being within the posterior fossa. These changes in the subarachnoid cisterns are therefore not useful for the precise localization of the expansive process

Cerebellar tumors, from a roentgenographic viewpoint may be classified into tumors situated in the midline and those lying in the cerebellar hemispheres. Tumors situated in the midline may further be divided into four sub-groups, namely, tumors in the vermis above the fastigium tumors in the vermis below the fastigium tumors ventral to the aqueduct and fourth ventricle and tumors in the collicular plate or around the aqueduct This is a routine method at our hospital of classifying the localization of expansive processes in the posterior fossa, and it is consequently used in this report

Roentgenographic changes

Tumors in the midline above the fastigium These tumors, as well as those in one or both cerebellar hemispheres, differ from tumors in the midline below the fastigium and from those situated ventral to the aqueduct and the fourth ventricle by the way in which they deform and displace the latter structures



a b c

Fig 1 Lumbar encephalography in a case of tumor of upper part of vermis a) Anterior kink in collicular plate b) Equal compression of the two pontocerebellar cisterns brain stem not deformed c) Ventriculography Kinking of aqueduct corresponds to kink in collicular plate

Tumors of the vermis above the fastigium push the fourth ventricle and the aqueduct anteriorly against the clivus so as to kink the aqueduct which is situated in the midline This kink arises between the two pairs of collicular bodies where the physiologic kink of the aqueduct is situated It has also been pointed out that the collicular plate is deformed in the same manner as the aqueduct by tumors located in the vermis and the cerebellar hemispheres (LINDGREN) The shape of the collicular plate even normally corresponds exactly to the shape of the aqueduct thus the collicular plate is shorter and the collicular bodies are higher when there is a physiologic kink of the aqueduct (LILIEQUIST) When the aqueduct is widened which is the case with a communicating hydrocephalus, it can be shown that the collicular plate is

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a b

Fig 5 Lumbar encephalography in a case of intrapontine tumor a) The collicular plate is pushed upwards much in the same way as in a lower vermis tumor b) The pons in the a p view is enlarged and deformed

were widened and pushed superiorly At operation the tumor was found to occupy the posterior part of the fourth ventricle

Tumors in the fourth ventricle mainly include medulloblastomas arising from the lower vermis and ependymomas originating from the floor of the fourth ventricle Like the choroid plexus papillomas they sometimes grow out through the foramen of Magendie to fill the cisterna magna and protrude downwards through the foramen magnum Tumors in this position are readily demonstrated by lumbar encephalography when they are capped with air in the cisterna magna They may thus be distinguished from tumors below the fastigium not growing out in the cisterna magna It is necessary to examine the fourth ventricle in order to demonstrate the upper limit of such a tumor the fourth ventricle is, however, surprisingly often filled with air even when the tumor has partially occupied the fourth ventricle

Tumors ventral to the aqueduct and the fourth ventricle Expansive processes in the pons give rise less frequently to increased intracranial pressure, as the circulation of the liquor is not obstructed It may be considered a general rule that it is possible to fill the fourth ventricle as well as the aqueduct with air by lumbar encephalography when the tumor is situated in the pons The position of the fourth ventricle which is lifted from the clivus is usually such that all the air injected regardless of the position of the head of the subject passes into the fourth ventricle and not into the subarachnoid cisterns When this does not occur pontine tumors may be recognized by changes in the surrounding subarachnoid cisterns The collicular plate may however in these tumors be deformed and displaced in a similar way as with tumors in the lower vermis and the fourth ventricle

Large acoustic neurinomas (usually growing posteriorly in the posterior cranial fossa) cause the same displacement of the fourth ventricle and a corresponding change in the shape and position of the collicular plate. As the tumor is extracerebellar it is, however, possible to demonstrate a tumor pole in the cistern and this is not possible when the tumor grows in the pons.

Fig. 5 is from a case in which the posterior part of the collicular plate was swung superiorly in much the same way as with the lower vermis tumors in the p.a. view, however, the pons was seen to be enlarged and deformed. Such large deformations of the pons and the brain stem are mainly seen with tumors growing in the pons and usually do not occur as a result of displacement caused by a tumor in the fourth ventricle or the lower vermis.

The writer in summarizing would like to emphasize that lumbar encephalography generally gives as much as, or more information than, ventriculography in tumors of the cerebellum. It is always possible by lumbar encephalography to establish the presence of an expansive process in the posterior cranial fossa. Expansive processes of the vermis and the hemispheres may be distinguished from tumors of the lower vermis and fourth ventricle as well as from those of the pons by examination of the collicular plate. Tumors of the upper part of the vermis may often, but not always, be distinguished from hemispheric tumors. Tumors of the pons give rise to the same changes in the collicular plate as those situated farther posteriorly. They deform the pons but seldom offer any hindrance to the passage of air into the fourth ventricle and aqueduct. Tumors which protrude into the cisterna magna are more readily diagnosed by lumbar encephalography than by ventriculography.

SUMMARY

The essential changes that occur in the cisterns with expansive processes of the cerebellum and that permit the localization of these tumors by lumbar encephalography are described. It is stressed that the method would appear to give more information than ventriculography in these conditions.

ZUSAMMENFASSUNG

Die charakteristischen Veranderungen der Cisternen bei Kleinhirntumoren nach lumbaler Encephalographie werden beschrieben. Es wird betont, dass die Methode m nder ... wertvolle aber meistens bessere Resultate ergibt als die Ventrikulographie.

RÉSUMÉ

L'auteur décrit les modifications essentielles qui se produisent dans les citernes da... de lésions expansives du cervelet qui permettent de localiser ces tumeurs par encéphalographie lombaire. Il souligne que cette méthode semble donner dans ces affections plus de renseignements que la ventriculographie.

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INFLUENCE OF VENTRICULAR SIZE ON MORTALITY AND MORBIDITY FOLLOWING VENTRICULOGRAPHY

by

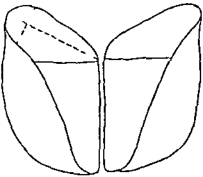
GIOVANNI MARINI and JUAN M TAVERAS

It has been generally accepted that cases with extremely large ventricles do not do as well following ventriculography and surgical intervention as others in whom the ventricles are not so enlarged (CUSHING 1902, GUTTMAN 1936, DAVID & ASKENASY 1937, CAIRNS 1939, OLIVECRONA 1940)

The purpose of this paper is to present an analysis of the mortality and morbidity in a group of cases in which the ventricles were markedly enlarged and to compare this with another similar group of cases in which the ventricles were only moderately enlarged

Material and method of selection Roentgen reports on all cases in which ventriculography was performed at the Neurological Institute of New York during the period 1949—1960 were examined for the selection It was necessary to limit the investigation to the last ten years because prior to that time some of the roentgen films were not available This was thought to be an advantage because the technique and indications for ventriculography have been uniform during recent years

A total of 1 943 ventriculographies had been performed In 1 040 cases evidence of a mass was detected all these cases were reviewed and only those in which the presence of marked ventricular dilatation was present were



Diagrammatic representation of method of measurement

selected for this study we therefore believe that nearly all the cases in which the ventricles were extremely large were probably included Cases of infantile hydrocephalus were however excluded The films were then reviewed and the ventricular size estimated by the following method

The lateral angle of the body of the ventricle was measured on a line per pendicular to the oblique diameter of the middle third of the body of the ventricle The actual measurement was made at a point 0 5 cm from the lateral angle as explained in a schematic figure

The upper limit for a normal measurement is under 1 0 cm In adults over 30 years of age it is considered to be 0 9 cm in young adults and in children the limit is considered to be 0 7 cm

The actual size of the enlarged ventricle is expressed from 1 to 4 plus, as follows

0 9 cm to 1 2 cm = 1 +
1 3 cm to 1 5 cm = 2 +
1 6 cm to 1 9 cm = 3 +
2 0 cm and over = 4 +

Only cases with a measurement across the lateral angle in the middle third of the body of the lateral ventricles of 20 mm or more were classed as having markedly enlarged ventricles The largest measurement encountered was 45 mm

A total of 55 cases with markedly enlarged ventricles was found It was then decided to match this group with another equal number of cases selected at random from the files of the department with a comparable pathologic condition but in which the ventricles were only moderately dilated This con trol group was spread over the same number of years five cases per year for eleven years

Table 1

Age distribution and results of surgical procedure

Group A—Extremely dilated ventricles 20 mm or more

Age	Died	Did well	Total
1 to 10 years	2	5	7
11 to 20 years	5	10	15
21 to 30 years	6*	5	11
31 to 40 years	2*	1	3
41 to 50 years	1	9	10
51 to 60 years	0	[illegible]	[illegible]
61 to 70 years	1	5	6

Group B—Moderately dilated ventricles 10 to 19 mm

Age	Died	Did well	Total
1 to 10 years	2*	0	[illegible]
11 to 20 years	1	12	13
21 to 30 years	0	4	4
31 to 40 years	1	8	9
41 to 50 years	0	7	7
51 to 60 years	3*	11	14
61 to 70 years	1	5	6

* In one case Severe post operative period but recovery followed

The material therefore consists of 110 cases all of which underwent ventriculography The ventricular size, estimated as described above, was 20 mm or more in a half of these cases, and we shall refer to these as group A the other half showed only moderately enlarged ventricles (10 to 19 mm) and these form group B (controls)

The postoperative course is given in Table 1 in relation to the age distribution, and in Table 2 in relation to the situation of the pathologic process It will be noted that all the cases except two, were of a posterior fossa or mid line lesion

In the majority of the third ventricle tumors the histologic diagnosis was not made because these cases are usually treated by a shunting procedure followed by radiotherapy (CUMMINS TAVERAS & SCHLESINGER 1960)

Material analysis

The operative mortality of the two groups of 55 cases was in the cases of group A 15 (27 4 %) and in the cases of group B 6 (10 9 %) The morbidity (severe postoperative course from which the patients recovered) was the same in the two groups 2 (0 04 %)

Table 2

Pathologic diagnoses and results of the surgical procedure

Group A Extremely dilated ventricles 20 mm or more	Died	Interval between surgical procedure and death	Did well
Cerebellar mass	5	2 hrs 1 day 2 days 3 days 14 days	12
Posterior fossa mass extra axial	1	2 days	6
Aqueductal stenosis	—		3
Brain stem mass	3	24 hrs 24 hrs 4 days	—
Third ventricle mass	2	2 days 3 days	17
Suprasellar mass	2	1 day 2 days	2
Unperforated 4th ventricle foramina	1	5 days	—
Previous trauma	1	2 days	—
Totals	15		40

Group B Moderately dilated ventricles 10 to 19 mm	Died	Interval between surgical procedure and death	Did well
Cerebellar mass	3	4 days 4 days 5 days	27
Posterior fossa mass extra axial	1	2 days	6
Aqueductal stenosis	—		2
Brain stem mass	—		2
Third ventricle mass	—		9
Suprasellar mass	1	1 day	3
Sphenoid ridge meningioma	1	2 weeks	—
Totals	6		49

The *amount of cerebrospinal fluid* removed during the ventriculographic procedure in the subjects of group A who died varied from 45 ml to 520 ml the average amount being 153 ml The amount of fluid removed in the subjects of group A who survived varied from 40 to 350 ml, but the average was only 124 ml

The fluid removed in the subjects of group B who died, varied from 20 to 130 ml with an average of 70 6 ml in the subjects of the same group who did well, the amount varied from 5 to 100 ml, the average being 66 ml

The ventricular size in the subjects of group A who died varied from 20 to 45 mm and the average was 28 mm in the subjects of the same group who did well the ventricular size varied from 20 to 35 mm the average being 23 7 mm

The cases of group B had ventricles all of which were reported as moderately enlarged (10 to 19 mm)

The *general condition* of the subjects before undergoing ventriculography and the subsequent surgical procedure was in group A described as drowsy for 6

only, and 3 of these died, while in group B, 15 were reported as in a poor condition (drowsy and dull) and 5 of these died

Papilledema of high degree (3 to 4 diopters with hemorrhages) was reported in 24 cases of group A and in 11 of group B

Two of the subjects of group A who died developed a massive bifrontal epidural hematoma and one of these also had a parietal hematoma These two cases have been reported elsewhere (HAFT, LISS & MOUNT 1960) Another case of the same group was found at autopsy to have an upward herniation of the cerebellum with compression of the brain stem similar to that usually found in hippocampal herniations The danger of upward cerebellar herniation through the tentorial incisura following ventriculography has been reported by CAIRNS (1929), JEFFERSON & JOHNSON (1950) and JEFFERSON (1951)

Discussion

It is apparent that there are difficulties in evaluating all the factors that may be involved in a group of cases of this type such as the condition of the cases before the procedure, the degree of involvement of vital structures and the experience of the operator It may be pointed out however, that cases with extreme ventricular dilatation usually have a benign lesion or a more slowly growing neoplasm than those of the other group

In trying to evaluate the condition of the subject before ventriculography we found that 49 of the group A cases were described in the clinical records as cooperative and 34 of them were under 31 years of age Only 40 were described in the control group as alert and cooperative

The majority of deaths in the subjects with markedly enlarged ventricles were in the younger group, the two who developed epidural hematomas were both 15 year old boys

Three of the 15 deaths in the group with markedly enlarged ventricles were among those described as drowsy the remaining 12 who died being alert and cooperative before the procedure On the other hand, in the groups of subjects with only moderate ventricular dilatation 15 were described as in poor condition and 4 of these died Four of the deaths thus occurred in subjects who were very ill This would suggest that a serious general condition prior to ventriculography and operative intervention bears a direct correlation with the final outcome even if the ventricles are not markedly dilated An extremely enlarged ventricular system appears however to constitute a significant sign and many subjects do not survive the procedure even if their preoperative condition was comparatively good If therefore it were concluded that the size of the ventricles at the time of ventriculography has no bearing on the final outcome this would mean that an important factor had been overlooked

All the cases included in this review were submitted to ventriculography performed as a routine procedure, that is, occipital burr holes were made the

ventricles were punctured and the exchange of fluid and gas was performed at the same time within a period of 10 to 30 minutes rarely longer Slightly less gas than fluid removed is usually injected, and the exchange is performed in multiples of 5 ml at the time No particular limitations are indicated at the Neurological Institute on the total amount of air and fluid to be exchanged but the smallest quantity which by the operating surgeon is considered sufficient for satisfactory roentgenograms is generally removed This explains the wide range encountered in the total volume of gas used in these cases the amount considered sufficient when deciding upon the program of roentgenograms depends on the personal experience of the operating surgeon

The question is whether a variation in the technique of ventriculography is justified in cases with extreme ventricular dilatation It may be said that the operator does not know the size of the ventricles before viewing the roentgen films There may, however be certain indications The conventional films may reveal an extreme degree of destruction of the sella turcica, and in some cases the convolutional markings will be prominent (hammered silver appearance) this latter sign develops only in long standing increase in intracranial pressure Some of these subjects particularly those in the younger group, have a large head The presence of erosion of the posterior portion of the anterior fossa, just anterior to the anterior clinoid process, is usually associated with a long standing increase in intracranial pressure, and the erosion of these areas may be due to pulsating dilated frontal horns

At the time of ventriculography the ventricles are entered more superficially than is usually the case possibly 3 cm from the cortex It should be pointed out that the ventricles may be entered superficially in cases of only moderately enlarged ventricles but with congenitally large occipital horns

The operator is often preoccupied only with the degree of pressure, as evidenced by the rate of escape of fluid at the time the ventricle is tapped If the ventricles are entered too superficially certain alternate courses are available as follows

1 Injection of 5 ml gas and one or more films taken to estimate ventricular size particularly that of the frontal horns if the ventricles are extremely large the subject is placed on drainage

2 Ventricular drainage for 12 to 24 hours before the ventriculography

3 Use of a positive contrast medium may sometimes be advocated we have rarely employed this procedure

4 Using a very small amount of gas when performing the ventriculography with this method it is difficult to obtain satisfactory roentgenograms as it requires a somersault technique which except in children cannot be performed without special apparatus

5 Azambuja et coll (1956) recommended in these cases the performance of ventriculography through frontal burr holes a soft catheter is slipped into the third ventricle through the dilated foramen of Monro and the sub

ject is then placed in the prone position and 10 ml of gas injected The gas outlines the posterior portion of the third ventricle, the aqueduct and the fourth ventricle (*central ventriculography*)

SUMMARY

A total of 1 943 consecutive ventriculograms were reviewed and evidence of an intracranial mass detected in 1 040 The ventricles were markedly enlarged in 55 cases which were compared with an equal number of cases in which the ventricles were only moderately enlarged The operation mortality in the first group of cases was 27 4 % and in the control group 10 9 % Possible explanations for these data are presented

ZUSAMMENFASSUNG

Insgesamt 1 943 fortlaufende Ventrikulographien zeigten 1 040 raumbeengende Tumoren Grobe Erweiterung der Ventrikelraume wurde in 55 Fallen gefunden und verglichen mit einer gleichen Zahl von nur leicht erweiterten Ventrikeln Die operative Mortalität in der ersten Gruppe war 27 4 % in der zweiten Gruppe 10 9 % Eine mogliche Erklarung für diesen Unterschied wird gegeben

RÉSUMÉ

Les auteurs ont revu un total de 1 943 ventriculographies consécutives et ont trouvé des signes de tumeur intracranienne dans 1 040 de ces cas Le volume des ventricules était notablement augmenté dans 55 cas qui ont été comparés à un nombre égal de cas ou les ventricules n étaient que modérément agrandis La mortalité opératoire a été de 27 4 % dans le premier groupe de cas et de 10 9 % dans le groupe témoin Les auteurs donnent des explications possibles de ces résultats

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FROM THE DEPARTMENT OF NERVOUS AND MENTAL DISEASES (DIRECTOR PROF. O. MALECI), UNIVERSITY HOSPITAL, FLORENCE, ITALY

ENCEPHALOGRAPHIC APPEARANCES IN SKULL INJURIES

by

W. PIAZZESI and G. CAMPANELLA

An investigation by means of encephalography was carried out in a group of subjects that had had persistent symptoms for a long period following a head injury. Similar studies have been performed by BETOULIERES et coll. (1955) and THIRY et coll. (1955).

Material and Method. Thirty seven patients varying in age from 35 to 54 years were examined. Injury to the skull had been sustained a year before admission in 6 of these, 18 months in 3, between two and three years in 19, between six and seven years in 6, and from fifteen to sixteen years in 3 patients. A cranial fracture had been recorded only in 9 of the patients; loss of consciousness lasting from two to seventy two hours had occurred in 6 patients, and from a few minutes to half an hour in another 6 patients, while there was a history of temporary black out in 15 patients. There had been no suggestion of any disturbance of consciousness in 10 patients. All patients had complained of constant or intermittent headache with occasional vomiting. The neurologic examination was negative in all patients and laboratory tests showed no abnormality. Twenty one patients were classed as being neurasthenic and 13 as hysterical.

The current fractional technique was employed. From 40 to 60 ml oxygen were injected after withdrawal of about half those amounts of cerebrospinal



Fig 1 a) Male aged 48 injured 14 months previously Symmetrical ventricular dilatation ventricles rounded and indented Evans index 0 37 b) Male aged 54 injured 16 years previously Asymmetrical ventricular dilatation with distinct deform[illegible] Evans index 0 33



Fig 2 Male aged 40 injured 2 years previously Asymmetrical ventricular dilatat[illegible] Evans index 0 36

fluid Standard projections with the patient sitting or recumbent were the rule, these were augmented when necessary with special views for the exam[illegible] tion of regions of particular interest

The appearances were in doubtful cases evaluated by means of the Evans index

Results and discussion

Marked ventricular dilatation with an Evans index of 0 36 to 0 3[illegible] was observed in 6 patients the ventricles were rounded, their margins inde[illegible] and fluid levels were present (Fig 1a) The dilatation was less marked [illegible]



a b c

Fig 3 a) Male aged 54 injured 2 years previously Slight ventricular dilatation Evan s index 0 31 b) and c) Male aged 50 injured 8 years previously Diffuse dilatation of the subarachnoid sulci Evan s index 0 31

patients the Evan s index being 0 33 in 12 of these the ventricles were regular in shape and symmetric and in the other 10 patients there was deformity (Fig 1b) or marked asymmetry of the ventricles (Fig 2) The dilatation was slight in 9 patients (Fig 3a) but in 3 of these dilatation of the subarachnoidal sulci of the skull was evident (Fig 3 b and c) Dilatation of the subarachnoidal spaces was noted in 15 patients and usually bore a relationship to the deformity and dilatation of the ventricles it was marked in 9 and moderate in 3 patients

Significant ventricular dilatation was observed in 67 % of the patients with cerebral disturbances following cranial injury The ventricular alterations may be explained by cerebral atrophy as an aftermath of a cicatricial lesion or due to primary injury to the encephalon The changes if due to cerebral atrophy would have been in a static phase while if caused by a cicatrix would probably have been progressive Primary injury to the brain on the other hand might have produced a hypersecretion of cerebrospinal fluid or obstruction of the liquoral routes in any event such effects would probably result in eventual cerebral atrophy This would appear to be confirmed by the relatively long time that elapsed between the injury and the establishment of the changes in the ventricles

In most of the cases the remarkably long period between the injury and the time the modifications were observed (average of two years) the presence of ventricular dilatations with deformity and sometimes with images of the pseudoporencephalic type, make possible the hypothesis of cerebral atrophy In the cases with slight symmetrical ventricular dilatation and with a shorter period from the injury, however the encephalographic findings presumably indicate an adaptation of the encephalon and of the liquoral cavities to variations in the liquor dynamics

SUMMARY

Encephalography was performed in 67 patients who had sustained cerebral injury from a year to 16 years previously and who had cerebral symptoms but no neurologic signs. The changes observed in the ventricles are described

ZUSAMMENFASSUNG

An 67 Patienten, die Hirnverletzungen erlitten hatten die zwischen einem Jahr und 16 Jahren zurucklagen und die cerebrale Beschwerden ohne neurologische Befunde hatten, wurden Encephalographien vorgenommen Die Rontgenbefunde wurden erörtert

RÉSUMÉ

Les auteurs ont fait une encéphalographie chez 67 malades qui avaient subi un traumatisme cérébral datant d un à 16 ans et qui présentaient des signes fonctionnels cérébraux sans signes neurologiques objectifs Ils décrivent les modifications ventriculaires qu ils ont trouvées.

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FROM UNIVERSITY OF ALBERTA HOSPITAL, EDMONTON, ALBERTA, CANADA

THE SUBARACHNOID CISTERNS IN INTRACRANIAL HYPERTENSION

by

H F W Pribram

Increasing popularity of fractional encephalography as the procedure of choice in the investigation of posterior fossa tumours has stimulated greater interest in the subarachnoid cisterns So much so that we may now with confidence make a positive diagnosis even in the absence of ventricular filling

The present study of 25 confirmed posterior fossa tumours was undertaken to determine the significance of the dilated subarachnoid cistern in the absence of ventricular filling at encephalography Our interest lies mainly in the callosal sulcus the ambient wings and the velum interpositum

The investigation was prompted by the following case

Case report

A male aged 45 was admitted to another hospital complaining of headache and impaired vision In addition he complained of noises in his ears and occasional loss of balance when walking and that he involuntarily stepped to the right at times He was a known hypertensive for 15 years and a chronic alcoholic

On examination the fundi showed marked bilateral papilloedema with haemorrhages and narrowing at the arteriovenous junctions There was a suggestion of nystagmus on looking to the left His blood pressure was 165/120 and a clinical diagnosis of hypertension with hypertensive encephalopathy was made

He was referred for neurosurgical opinion and was found to show some impairment of rapidly alternating movements of the right hand His blood pressure at that examination



Fig 1 Encephalography Dilated and stretched callosal sulcus in a case of fourth ventricle tumour

was 188/130 The opinion was expressed that the retinopathy would prove to be due to arterial hypertension and air encephalography was performed At this examination the ventricles failed to fill and bilateral carotid arteriography was performed

The films were referred for a second opinion and the findings were as follows the only abnormality seen on angiography was that the pericallosal artery was stretched and bowed indicating a considerable degree of hydrocephalus

The air study showed the cerebellar tonsils to be grossly herniated and the pontine cistern to be almost completely obliterated The callosal sulci were midline but markedly dilated so that in the anteroposterior view the pericallosal arteries were outlined In addition they were stretched and bowed upwards confirming the angiographic impression of hydrocephalus The left ambient cistern was dilated An unequivocal diagnosis of posterior fossa tumour was made

The patient was discharged from hospital and returned to work His blood pressure returned to normal levels under treatment His papilloedema remained unchanged

In view of the opinion expressed on these air studies the patient was eventually admitted to the University Hospital and meantime there had been further loss of vision

Ventriculography was performed and showed gross hydrocephalus with displacement of the aqueduct and 4th ventricle to the left side but the main displacement was forwards and downwards The appearances were confirmed by tomography and a diagnosis of tentorial meningioma on the right side was made This was confirmed at operation

In 1958 SCHECHTER and his associates described dilatation of the sulcus corporis callosi as a sign of hydrocephalus Such dilatation was present in 14 out of the 25 cases (Fig 1) In addition it was noted in one pituitary tumour which had obstructed the foramen of Monro

In a study of 200 normal encephalograms dilatation of the pericallosal cistern was present on only one occasion Since dilatation of the callosal sulcus may also be seen in cerebral atrophy a hundred such cases were examined



Fig 2 Ventriculography in the brow-down position The posterior part of the dilated callosal sulci was filled at previous encephalography



Fig 3 Myodil ventriculography in a case of fourth ventricle tumour Callosal sulcus dilated (filled at previous encephalography) Aqueduct angled as in a cerebellar or vermis tumour it is also dilated

and dilatation noted in 13 At the same time brains coming to autopsy were examined These showed that even in cases with considerable cortical atrophy, dilatation of the callosal sulcus was not a striking feature

Attention was then directed towards air studies with failure of ventricular filling, later classified as normal or as showing cerebral atrophy In these cases a determined attempt was made to demonstrate the pericallosal cistern Dilatation of the callosal sulcus was noted in all three of the encephalographies with non filling of the ventricles with a diagnosis of cerebral atrophy but on only two occasions in 16 such examinations which were considered to be normal

It seemed of some interest to determine whether dilatation of the callosal sulcus was of any localizing value but here the data was inconclusive There was a tendency for the contralateral callosal cistern to dilate but sometimes both and occasionally the ipsilateral one would distend

It is noteworthy that in the cases studied dilatation was most marked in the posterior part of the callosal sulcus (Fig 2) This would tend to suggest that obstruction in the region of the cisterna vena magna plays some part in causing dilatation of the callosal sulcus Such obstruction may be caused by displacement of normal structures such as the cerebellar vermis (Figs 3 and 4)

These observations should lead us to suspect the presence of a tumour when dilatation of the callosal sulcus is demonstrated at encephalography rather than to dismiss the appearances as being due to cortical atrophy There appears to be no way of differentiating the two conditions nor is dilatation of the callosal sulcus confined to posterior fossa tumours On several occasions it was seen in supratentorial tumours and in these cases there was displacement and distention of the contralateral callosal sulcus



Fig 4 Brain section in a case of fourth ventricle tumour Angulation and dilatation of the aqueduct as well as upward displacement of the vermis The callosal cistern is dilated



Fig 5 Encephalography Dilated cisterna veli interpositi in a case of posterior fossa tumour

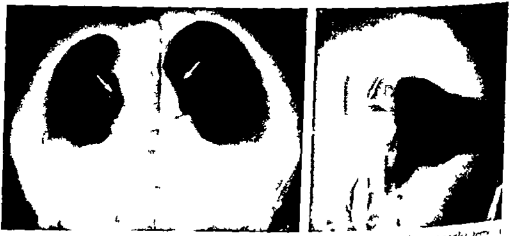
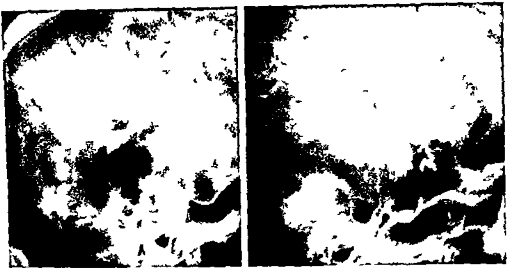


Fig 6 Ventriculography in posterior fossa tumour brow-down position Dilated cisterna veli [illegible] filled at previous encephalography

The ambient wings as described by LILIEQUIST are formed by a double fold of pia mater that extends backwards, outwards and downwards around the thalamus, that part of the cistern above the third ventricle being known as the cisterna veli interpositi Dilatation of the ambient wings and the cisterna veli interpositi (Figs 5 and 6) was observed in 10 of the 25 cases Again dilatation of the ambient wings was not found to be of localizing value

In none of the normal encephalograms, and on only one occasion [illegible] the cases of cerebral atrophy was dilatation of the velum interpositum [illegible]



a b

Fig 7 Case of arachnoid cyst a) Encephalography Ambient cistern dilated semi lunar erosion of the dorsum sella b) Carotid arteriography Elevation of middle cerebral artery and unfolding of carotid siphon choroidal vessels stretched

This was a mentally retarded 6 months old baby with tremendous dilatation of the cortical subarachnoid channels the callosal sulcus and the velum interpositum Similar findings have been described by ZELLWEGER but it is particularly in such a case that a posterior fossa tumour may be missed

In the course of this study, two cases were observed which illustrate that not only may dilatation of the subarachnoid cistern be an indication of hydrocephalus but that on occasion it is the cause In the literature may be found reports of six cases of arachnoid cyst of the ambient cistern, these two additional cases being observed in a child of three months and a woman of 22

The latter presented with papilloedema and a history of psycho-motor seizures At encephalography little filling of the ventricular system was obtained but a dilated ambient cistern was demonstrated (Fig 7a) Carotid arteriography on the right side revealed unfolding of the carotid siphon and elevation of the middle cerebral artery (Fig 7b) At ventriculography the right temporal horn was seen to be displaced upwards and laterally (Fig 8a) and the third ventricle was elevated and shifted to the left (Fig 8b) whilst the aqueduct and fourth ventricle were displaced backwards (Fig 8c) An arachnoid cyst of the ambient cistern was filled (Fig 8d)

At operation it was found medial to the right temporal lobe and contained clear cerebrospinal fluid

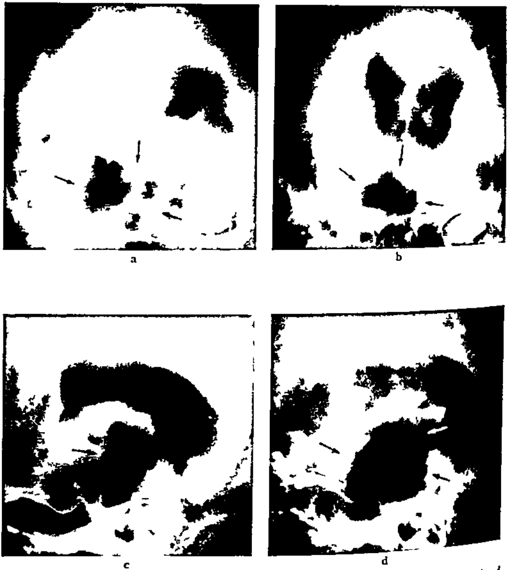


Fig 8 Same case of arachnoid cyst as in fig 7 a) Ventriculography in brow-down position [illegible] cyst of ambient cistern with lateral displacement of the temporal horn b) Ventriculography in the brow up position Displacement of the third ventricle upwards and to the left c) Brow-down film showing backward displacement of the aqueduct and fourth ventricle and partial filling of the arachnoid cyst d) Lateral film showing complete filling of the cyst

OLIVER distinguishes between primary and secondary arachnoid cysts. In the latter trauma or infection are thought to play a role whilst in the former group no such history is available The present cases fulfil the category of primary arachnoid cysts and the diagnosis should be kept in mind because relief of hydrocephalus may be achieved merely by unroofing the cyst

SUMMARY

It is concluded from this study that dilatation of the callosal sulcus and/or the ambient wings is suggestive of increased intracranial pressure Dilatation of the callosal sulcus may also occur in cerebral atrophy but the appearances should not be ascribed to this condition without further investigation Unfortunately these findings are not of localizing value Attention is drawn to the possibility of confusion with cases of arachnoid cyst

ZUSAMMENFASSUNG

An Hand von vorliegender Studie wird geschlossen dass die Erweiterung der Flugel der Cisterne ambiens mit oder ohne Erweiterung des Sulcus callosus auf einen Anstieg des intra kraniellen Druckes schliessen lasst Dilatation des Sulcus callosus kann auch bei cerebraler Atrophie vorkommen darf aber ohne Vorliegen anderer Untersuchungsergebnisse nicht als solche diagnostiziert werden Leider geben diese Befunde keinen Hinweis der Lokalisation Vorsicht vor Verwechslung mit arachnoiden Cysten ist angezeigt

RÉSUMÉ

La conclusion de cette étude est que la dilatation de la citerne péricalleuse et/ou des citernes rétropulvinariennes (ailes des citernes ambiantes) est un signe d hypertension intracranienne La dilatation de la citerne péricalleuse peut aussi exister dans l atrophie cérébrale mais ne doit pas être rapportée à cette affection sans autre examen Ces signes n ont malheureusement pas de valeur localisatrice L auteur attire l attention sur la confusion possible avec des cas de kyste arachnoïdien

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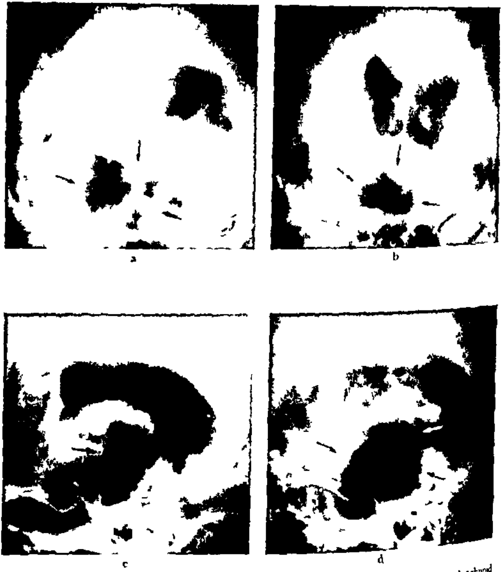


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Oliver distinguishes between primary and secondary arachnoid cysts In the latter, trauma or infection are thought to play a role whilst in the former group no such history is available The present cases fulfil the category of primary arachnoid cysts and the diagnosis should be kept in mind because relief of hydrocephalus may be achieved merely by unroofing the cyst



a



b



c

Fig 1 a) Dilatation and increased bulging of the callosal cistern ambient wings involved to a lesser degree b) P a projection with rabbit's ear sign of the dilated callosal cistern c) Pneumographic reproduction of the tela chorioidea prosencephali (From Fortschr Röntgenstr 94 (1961) 369)

The rather complicated anatomy of the essential structures will be briefly described Tela chorioidea prosencephali is a leptomeningeal plate of triangular shape enclosing a slit like subarachnoid space filling in the rostral part of the telodiencephalic fissure (fissura transversa cerebri), the dorsal part of which is occupied by the tentorium The gross form of this plate is shown in Fig 2 reproduced from WETZEL (1934) in which the two main constituent parts treated separately in most textbooks of anatomy, may be seen, viz the velum interpositum situated above the thalami and third ventricle (in the older anatomical literature termed tela chorioidea ventriculi tertii) and the paired ambient wings each extending around the pulvinar thalami and along the medial aspect of the temporal horn finally to merge with the Sylvian fissure The *continuity with the* general subarachnoid space *is* evident *also dorsally*, where the transition into the quadrigeminal cistern is indicated

Dilatation of cisternal spaces, i e an external hydrocephalus at once suggests the possibility of an atrophic process In the presence of a coexisting internal obstructive hydrocephalus this external accumulation of fluid how ever is difficult to explain since narrowing and flattening of the cisternal spaces

with expulsion of the fluid is then usually found We do not share the opinion that this cisternal dilatation may be caused only by the pressure of the air introduced (Sassaroli 1955), some pre existing dilatation of the spaces appears to be a more likely explanation

It would appear to the writer that this paradoxical phenomenon is due to the ascending transtentorial herniation of the cerebellum in conjunction with the peculiar anatomical construction of the tentorial opening This latter is not a plane structure but a spatial one, the apex incisurae representing the highest point and closely resembling the tip of a ski pointing occipitally (Villiger & Ludwig 1946) (Fig 3) The position of the apex proper is virtually much higher than is generally assumed although it stands out quite clearly in the late cerebral phlebogram as the confluence of the great vein of Galen with the straight sinus It is therefore not difficult to imagine that with ascending transtentorial herniation of the cerebellum and the brain stem setting in sooner or later in the course of an infratentorial space-occupying process and progressively obstructing the space along the margins of the tentorial notch (Bichat s fissure) by clinging closely to them the passage through the tentorial opening will be finally restricted to the apex Should the pontine cistern also be obstructed, the fluid from the posterior fossa — under normal conditions streaming freely through the incisura to the convexity of the cerebral hemispheres — will be directed through the only remaining free opening into the median and para median supratentorial cisternal spaces, the mouths of these open in close proximity to the apex the local over supply and steady impact of the liquor resulting in their progressive dilatation (Fig 4)

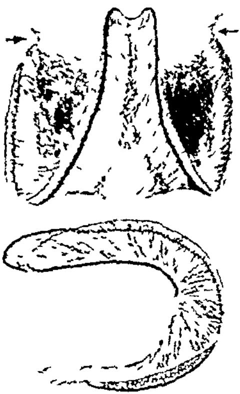


Fig 2 Tela chorioidea prosencephali viewed from above and from the side It merges with the Bichat fissure and quadrigeminal cistern (arrow) (From Wetzel 1934

A systematic study of these cisternal findings may indicate, or at least may draw attention to, the possibility of a subtentorial expansive process being present A prerequisite is knowledge of the normal appearances and above all, of the borderline of the normal — a difficult matter having due regard to the well known variability of the cisterns From a survey of one hundred

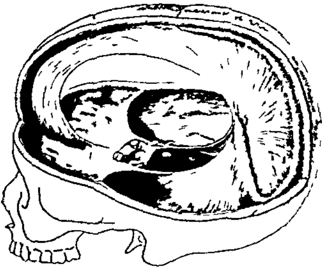


Fig 3 The apex represents the highest point of the tentorial opening with a mass progressively blocking the incisura from below the apex remains patent the longest (From VILLIGER & LUDWIG 1946)

normal encephalograms the writer came to the conclusion however that the subarachnoid space of the ambient wings and callosal cistern is normally narrow and slitlike and that the transverse diameter at the level of the maximal convexity of the former or of the perisplenial part of the latter does not usually exceed 2 mm It would therefore appear that an increase in this figure suggests a space occupying lesion in the posterior fossa

Fig 5 is from lumbar encephalography of a man aged 41, with a clinical posterior fossa syndrome and blurred papillae in which slightly widened ambient wings and the perisplenial part of the callosal cistern (over 2 mm) were evident The velum interpositum is open the supracerebellar cistern widened and the outline of the fourth ventricle cannot be identified The patient refused operation Assimilation of the atlas was present and a mild degree of basilar impression, with possible concomitant anomalies of the meningeal and/or nervous structures, which probably caused the cisternal dilatation BROCHER (1955) commenting on basilar impression stated (p 39)

Die Verkurzung des senkrechten Durchmessers (der hinteren Schadelhohle) muss sich besonders an der Medulla oblongata und am Kleinhirn auswirken da diese Gebilde gegen das unnachgiebige Tentorium cerebelli gepresst werden

Fig 6a is from a boy aged 8 years It shows unmistakable dilatation of the ambient wing cistern in the presence of a brain stem tumour producing blockage of the tentorial notch with the exception of the apex this was confirmed at further encephalography a few days later (Fig 6b) We failed

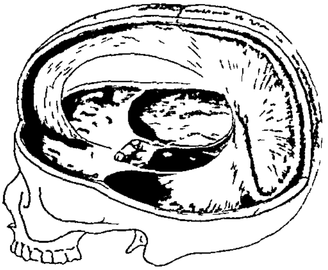


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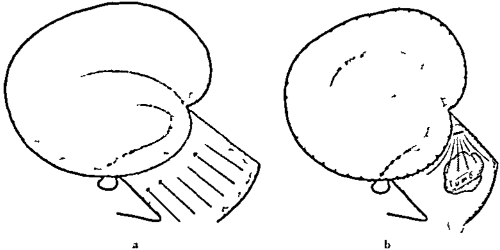
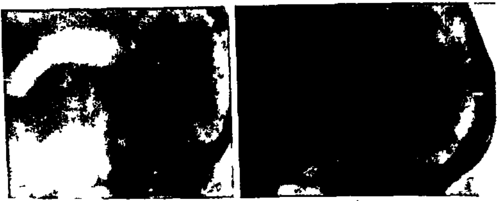


Fig 4 a) Normal relations of the supra and infratentorial external spaces freely communicating through the tentorial opening (arrows indicate the direction of flow of the cerebrospinal fluid The Sylvian fissure communicating with the subarachnoid space of the tela chorioidea prosencephali is sketched above the sella b) Increased contents of the posterior fossa due to an expansive process with herniation of the tonsils and compression of the pontine cistern The upper surface of the cerebellum clings tightly to the margins of the incisura from below the cerebrum expands owing to developing obstructive hydrocephalus so that finally only the apex remains free The fluid, taking this course (arrows) will be directed into the nearest i e the median and paramedian external spaces resulting in their dilatation owing to local over supply and steady impact of the fluid. (From Fortschr Röntgenstr 91 (1961) 369)



Fig 5 Distinctly widened supracerebellar cistern *ambient wings* and perisplenial part of the callosal cistern Apparent assimilation of the atlas slight basilar impression

to demonstrate the fourth ventricle (the air escaped into the lateral ventricles in the course of the rather difficult positioning of the head) and the dilated ambient wing cistern was *the only sign pointing* to the presence of a posterior fossa expanding lesion

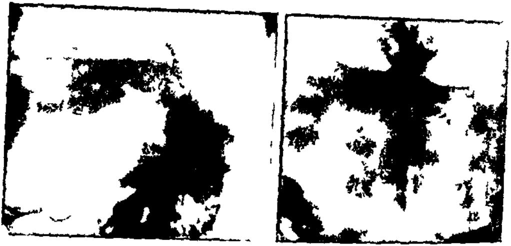


a b

Fig 6 Dilatation of the ambient wing cistern caused by a brain stem tumor

Fig 7 is from a boy aged 9 years with a short history suggesting a posterior fossa lesion The fourth ventricle (Fig 7a) is again not outlined, although the air freely enters the hydrocephalic lateral ventricles The ambient wing cisterns however are obviously dilated their maximal transverse diameter reaching 4 mm the perisplenial part of the callosal cistern is similarly affected The basilar artery can be seen pressed to the clivus in the slightly narrowed pontine cistern In the p a projection (Fig 7b), apart from marked internal hydrocephalus a unilaterally airfilled widened callosal sulcus is seen ('rabbit's ear') The fact that the vallecula was not displaced was difficult to expl... but its obvious narrowing was in keeping with the other cisternal changes a... indicated a posterior fossa space occupying lesion At operation an epen... moma the size of an egg was found at the base of the right posterior f... almost completely extracerebellar

Fig 8 is from a man, aged 52 with probable cerebral metasta... carcinoma of the stomach The supracerebellar and quadrigeminal... are greatly dilated suggesting at first the presence of an atrophic... The splenium of the corpus callosum bulges into the cistern and is... in the fluid The callosal cistern and ambient wings are distinctly dil... former displaying slightly accentuated arching evidenced by effa... the physiologic depression of the cistern anterior to the splenium T... interpositum is open and the cingulate sulci stand out clear... further course of the encephalographic examination a relatively ... of air entered the slightly hydrocephalic lateral ventricles whic... no expansive signs A posterior fossa expansive lesion was sugge... be mentioned that bilateral carotid angiography revealed ... deviation of the anterior cerebral artery to the right without fur... signs The patient died two weeks later At autopsy two orga... hematomas one in the left middle and one in the posterior cra... found there were no metastases



a b

Fig 7 a) Ambient wings and callosal cistern dilated basilar artery pressed to the clivus b P.a. projection Right sided ral b.rs car sign internal hydrocephalus vallecula narrowed

The encephalographic appearances in the last case may be better understood in the light of the autopsy findings The typical cisternal dilatation was obviously caused by the disturbed cerebrospinal flow at the level of the tentorial opening provoked by the subdural hematoma in the posterior fossa In the majority of cases a constantly and relatively rapidly enlarging lesion (tumor) in the posterior fossa leads at a rather early stage of development to a pressure obliteration of the supracerebellar and the quadrigeminal cisterns

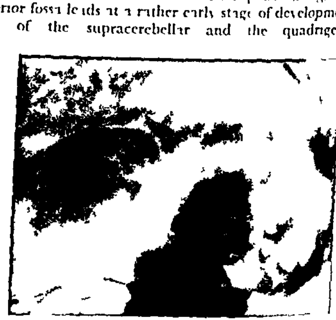


Fig 8 Supracerebellar and quadrigeminal cisterns greatly dilated callosal velum interpositum and ambient wings cisterns involved to a lesser degree splenium bathing in the fluid slightly increased arching of callosal cistern

However, with a more stationary expansive process represented in this case by the partially organised subdural hematoma this obliterating effect does not take place and the cisterns involved are able to dilate at the expense of the cerebellar tissue This dilatation is brought about by the fluid which, directed towards the apex incisurae, pools in front of it the term prestenotic dilatation might be used The stenosis is represented by the apex more or less narrowed by the herniating cerebellar tissue, and/or by the resistance offered to the cerebrospinal fluid from the supratentorial space through the apex

The aim of the present communication has been to show that air filling of the cisternal spaces may give an indication of the existence of a lesion in the posterior fossa

SUMMARY

An explanation is advanced of the paradoxical dilatation of the median the paramedian supratentorial and to some degree the infratentorial cisternal spaces demonstrated by ence phalography in pace-occupying lesions of the posterior fossa Possible differences in the cisternal appearances in progressive and more stationary infratentorial space-occupying processes are considered

ZUSAMMENFASSUNG

Eine mogliche Erklarung wird beschrieben fur die paradoxe Erweiterung der medialen paramedial supratentorialen und mit gewissen Einschrankungen der infratentorialen Zi sternen wie sie bei der Enzephalographie bei Tumoren der hinteren Schadelgrube gefunden wird Moglicherweise kommen Unterschiede vor je nachdem ob die Tumoren stationar oder progressiv sind

RÉSUMÉ

L auteur propose une explication de la dilatation paradoxale des espaces cisternaux supra tentoriels médians et paramédians et dans une certaine mesure des citernes sous tentorielles que l encéphalographie montre dans les tumeurs de la fosse postérieure Il examine la pos sibilité de différence des images cisternales suivant que les tumeurs sous tentorielles évoluent plus ou moins rapidement

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FROM THE DEPARTMENTS OF RADIOLOGY AND NEUROLOGICAL SURGERY, RADCLIFFE INFIRMARY, OXFORD, ENGLAND

VENTRICULAR DILATATION MASKING THE PRESENCE OF CEREBRAL TUMOURS

by

PHILIP SHELDON and A. K. OMMAYA

There is no doubt that the efficiency of neuroradiologic techniques has made the diagnosis of intracranial expanding lesions both more accurate and possible earlier in their history. However, even now, an early expanding lesion may escape detection by both the chief methods of investigation, i.e. encephalography and angiography.

This paper deals not with normal appearances in such cases, but with cases in which the investigations, especially encephalography, might be considered frankly misleading. We have encountered a small group of cases with proved space occupying lesions in the cerebral hemispheres who rather than showing the expected displacements at encephalography present initially with dilatation of the lateral ventricle on the side of the mass, leading in some cases to a primary diagnosis of cerebral atrophy. We now consider that such appearances may occur more frequently than we at first supposed. However, only one reference to this finding has been discovered in the literature (ROBERTSON 1957).

On the other hand, reviewing various papers in which it has been claimed that normal encephalograms were obtained in the presence of tumours, we have been struck by several illustrations in which unremarked ventricular dilatation on the side of the supposed mass (e. g. Fig. 8 in WICKBOM 1956) is apparent.

The following cases illustrate the diagnostic problems which may be encountered.





Fig 1 Case 1 Left carotid angiography Probable evidence of small left temporo-parietal mass See also figs 2 and 3

Case reports

Case 1 A right handed car maker aged 55 One year previously he had had a carcinoma of the sigmoid colon removed Four months after this he had considerable difficulty in the ability to speak and write Headaches were frequent and he became disorientated A diagnosis of a left frontal metastatic tumour was made Blood pressure was normal

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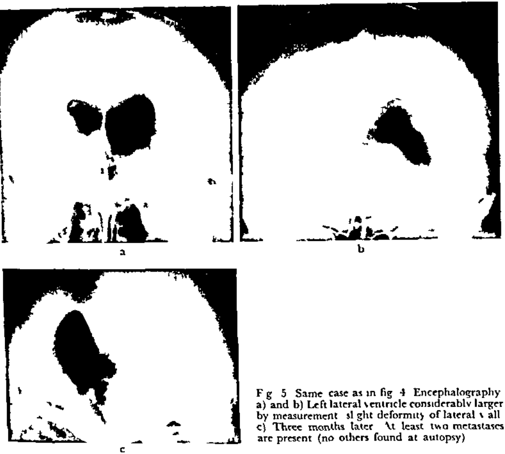


Fig 5 Same case as in fig 4 Encephalography a) and b) Left lateral ventricle considerably larger by measurement slight deformity of lateral wall c) Three months later At least two metastases are present (no others found at autopsy)

Radiologic investigations On admission to our hospital angiography showed what was taken to be evidence of a small space occupying lesion in the left posterior parieto-temporal region (Fig 1) there being slight stretching of the branches of the middle cerebral artery in that area and minimal displacement of the pericallosal artery and internal cerebral vein to the right There was also a suggestion of abnormal circulation in the same area

However encephalography (Fig 2) showed dilatation of the lateral ventricles this being marked on the left side The height and width of the lateral ventricle on the left side was between 5 and 8 mm greater than on the right side The septum pellucidum lay virtually in the middle line and any shift was ascribed to the greater dilatation of the left lateral ventricle On account of these films the angiographic changes were disregarded it being considered unlikely that a mass as indicated in the angiogram would not cause some deformity of the ventricles

In view of this finding of ventricular dilatation more marked in the suspected hemisphere it was wrongly felt that a metastatic or other space occupying lesion was not present The patient was allowed to go home but as he became more obtunded and his speech showed greater impoverishment he was readmitted two months later with marked dysphasia a right sensori motor hemiparesis and a right homonymous hemianopia but no papilloedema Investigations on this occasion were as follows



Fig C Case 3 Left carotid angiography Slight kinking of genu of pericallosal artery to the right and possible stretching of prerolandic branches of middle cerebral artery Compare also Fig ?

At encephalography carried out three months after the first series marked displacement of the septum pellucidum to the right was observed No filling of the left lateral ventricle was obtained and repeated angiography showed that there was now a large parietal mass (Fig 3)

This was confirmed as being a tumour by a burr hole biopsy when the histologic evidence revealed it to be a secondary carcinoma

Post mortem examination two weeks later revealed a large left posterior temporo-parietal tumour with considerable swelling of the remainder of the brain There was no evidence of any obstruction to the flow of cerebrospinal fluid through and out of the ventricles and no other metastatic lesion was found

Case ? A lorry driver aged 58 began to suffer from focal fits involving the right side of his body without loss of consciousness four months before coming to hospital At examination only a minimal right facial weakness and a blood pressure of 2?8/110 were found

Radiologic investigations A left carotid angiogram was considered to be normal (Fig 4) The pericallosal artery ran a somewhat irregular wavy course but this was rather similar to other intracranial arteries and considered to be a manifestation of cerebral atherosclerosis The internal cerebral vein was in the mid line

At encephalography on the same day general dilatation of the lateral and third ventricles (Fig 5 a and b) was observed This however was more marked on the left side than the right especially posteriorly and there may have been displacement of the septum pellucidum of about 1 mm to the right The width of the left lateral ventricle was up to 7 mm greater than the right and the height 3 mm greater There was a slight indentation of the outer border of the body of the left lateral ventricle anteriorly The appearances were considered to be due to cerebral atrophy probably due to cerebrovascular disease not enough attention being paid to the indentation of the left lateral ventricle

Three months later he was readmitted to hospital at this time he was comatose and had bilateral papilloedema and a right sensori motor hemiparesis Angiography showed a large space occupying lesion in the left upper frontal region with no obviously abnormal circulation



b



c

Fig 7 Same case as in fig 6 a) and b) Encephalography Lateral ventricle on left appreciably larger than on right side (5 to 8 mm) and central septum no deformity c) Angiography Six weeks later Extensive malignant circulation in left frontal region

Ventriculography was also carried out on the same day and this showed that in fact there were at least two separate lesions (Fig 5 c) These were metastatic carcinomata from a small oat cell tumour of the right main bronchus No others were found at autopsy

Case 3 A man aged 53 years Three months before admission he noticed increasing difficulty in writing typing and expression in speech This deterioration was progressive Episodes of sudden transient confusion and speech disturbance occurred two weeks before admission No papilloedema was present The blood pressure was 198/110 mm Hg A provisional diagnosis of left frontal tumour was made

Radiologic investigations The first angiography carried out was considered to be almost normal (Fig 6) The pericallosal artery might possibly in retrospect have been about 1 to 2 mm to the right of the mid line in the sagittal view The internal cerebral vein lay in the mid line There was no suggestion of abnormal circulation The encephalographic examination (Fig 7 a and b) showed general virtually symmetrical dilatation of the lateral and third ventricles there being rather more dilatation of the posterior part of the body of the left lateral ventricle than the remainder of the bodies of the ventricles The septum pellucidum was undisplaced The temporal horn also appeared to be normal In view of the general dilatation rather more marked on the left side the appearances were considered to be due

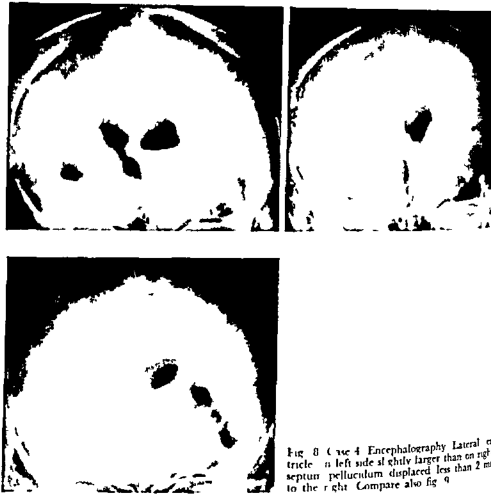


Fig. 8. Case 4. Encephalography. Lateral ventricle on left side slightly larger than on right; septum pellucidum displaced less than 2 mm to the right. Compare also fig. 9.

to cerebral atrophy. The left body in general was between 4 to 8 mm greater in height and width.

In view of these findings this patient was discharged with a view to follow up in the out patient department, but the neurological deficit progressed so rapidly that he was readmitted to hospital after one month.

Another angiographic examination (Fig. 7c) was carried out only six weeks after the first one. This showed extensive pathologic circulation in the fronto-parietal region of the left side with considerable displacement of the pericallosal artery to the right and stretching of the branches of the middle cerebral artery in the area affected. A biopsy of the tumour was taken and this was reported as a malignant glioma.

Case 4. A girl of 17 years from another country had a history of 6 months with signs pointing to a left fronto-parietal space-occupying lesion.

A very adequate encephalographic examination, carried out in her own country, had shown the lateral ventricles to be virtually symmetrical at first sight, but in fact the transverse diameter of the left side was 4 to 5 mm greater than of the right side anteriorly and posteriorly

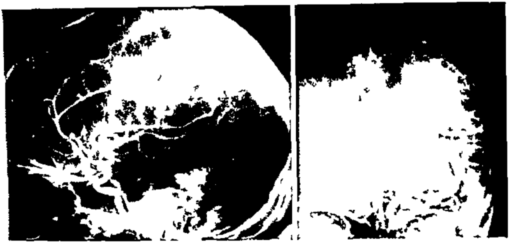


Fig 9 Same case as in fig 8 Left carotid angiography Large left upper parietal glioma containing fine pathologic vessels

(Fig 8) There was no deformity of the left lateral ventricle the third ventricle was in the midline but the upper part of the septum pellucidum was displaced 1 to 2 mm to the right

We were on these findings quite prepared to find a mass and so it turned out Carotid angiography was carried out in our hospital a few days later (Fig 9) during which time the patient s condition was unchanged and a large fronto-parietal tumour containing small abnormal vessels was found This was extirpated and proved to be an astrocytoma

Discussion

The practical applications of our observations are demonstrated by the fourth case In all the four cases described there was slight or moderate dilatation of the lateral ventricles on the side of a mass at intervals of three weeks to six months before a second series of investigations showed incontrovertible evidence of a space occupying lesion in all cases signs and symptoms of the disease were exhibited for at least three to four months We do not know whether this dilatation was fortuitous or in some way due to the tumour In any case in the first few cases in which we noticed this phenomenon it caused confusion in the diagnosis, being labelled as cerebral atrophy We have had six known cases in two years but have not yet examined our previous material

We do not now believe it to be due to pre existing atrophy since it has been seen in young patients — one here mentioned being only 17 years old and a child of 10 years of age showed similar changes but as yet unproven We do not think it is due to obstruction of the foramen of Monro nor of any other part of the ventricular system One cannot invoke the theory that tumours

involving the choroid plexus cause overproduction of cerebrospinal fluid. We also do not like to believe that an error in technique produced the appearances.

It has been suggested to us that degeneration occurred at an early stage in the tumour, or that they were preceded by a pre-neoplastic stage of cerebral atrophy. This is highly speculative and to us sounds unlikely.

We realise that most of the appearances described here can be seen amongst cases with cerebrovascular disease, the problem being how to differentiate between such cases. It would seem that slight lateral displacement of the septum pellucidum found at encephalography, together with slight lateral displacement of the internal cerebral vein in an angiogram, is significant of a mass, although displacement of the septum pellucidum and of the pericallosal artery in cases of dilated ventricles is not so significant. Even more significant is increasing displacement during the course of an examination, this being the change described by RUGGIERO and SMALTINO (1960) as occurring 24 hours later, but in our practice it has been seen frequently to occur within one hour (cf. Fig. 2c). Nowadays, if we suspect a tumour and find an enlarged ventricle on the side on which the tumour should be, even though there is no displacement of the septum pellucidum, we make sure of obtaining films after an interval of several hours. Four of our seven cases have shown either increase or development of shift.

We have learned at least one important fact from our observations — one should be very careful of making a diagnosis of cerebral atrophy, or cerebrovascular disease, especially unilateral, in the presence of localized and progressive clinical signs and symptoms, even though the ventricle on the affected side be dilated and larger than that on the normal side.

Acknowledgements

The authors wish to acknowledge the help given by Dr E. H. Kemp and Mr J. B. Pen-backer.

SUMMARY

Four cases are described in which unilateral ventricular dilatation had an ipsilateral cerebral tumour. The differentiation between such cases and cerebral atrophy is discussed.

ZUSAMMENFASSUNG

Es werden 4 Fälle beschrieben, bei denen einseitige Ventrikeldilatation einen ipsilateralen Hirntumor versteckte. Die Differenzialdiagnose zwischen solchen Tumoren und cerebraler Atrophie wird besprochen.

RÉSUMÉ

Les auteurs presentent quatre cas ou une dilatation ventriculaire unilaterale cachait une tumeur cérébrale du même coté Ils étudient le diagnostic différentiel entre ces cas et l atrophie cerebrale

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PNEUMOSTRATIGRAPHIE SAGITTALE MÉDIANE DE LA FOSSE POSTÉRIEURE

par

F. THIÉBAUT, A. WACKENHEIM et C. VROUSOS

Depuis 1958 *nous* étudions la radioanatomie normale et pathologique de la fosse *postérieure* avec une méthode pneumostratigraphique que nous avons mise *au point*. Les modalités techniques et les résultats ont été exposés dans plusieurs articles antérieurs de sorte que nous n'y revenons pas (voir bibliographie). Sa facilité de réalisation pratique est telle que la pneumostratigraphie sagittale *médiane* de la fosse postérieure est devenue pour nous une exploration *de routine* quotidienne pratiquée au début de toute encéphalographie gazeuse fractionnée. Le premier cliché nous donne en effet une très grande sécurité pour le diagnostic des hernies amygdaliennes (THIÉBAUT, WACKENHEIM & VROUSOS, 1961) et fournit en outre des renseignements très précieux sur la radioanatomie des éléments pneumographiques du plan sagittal médian de la fosse postérieure.

A notre avis, toute investigation encéphalographique doit commencer avant la soustraction liquidienne par la pneumostratigraphie sagittale médiane. D'autres coupes tomographiques seront réalisées à la demande. Après cette première phase tomographique nous poursuivons l'examen avec les clichés classiques de l'encéphalographie gazeuse fractionnée.

Nous rapportons quelques clichés qui illustrent particulièrement bien la valeur diagnostique de notre technique pneumostratigraphique. Les exemples rapportés ne pourront malheureusement pas être reproduits ici en totalité.



Fig 1 Cyclocervelet Malformation congenitale caracterisee par la fusion de deux hémisphères cérébelleux en une sphere avec absence du vermis (verification anatomique) Absence du sillon transverse anterieur de Vicq d Azyr traduisant l absence du vermis et l aspect arrondi du toit du IVème ventricule



Fig 2 Atrophie cerebelleuse tardive à predominance vermienne de type Pierre Marie Foix et Alajouanine Les sillons vermiens sont larges predominance de l atrophie corticale au niveau du culmen et declive





Fig 3 Atrophie cerebelleuse d un enfant de 10 ans presentant un syndrome cerebelleux diffus à predominance statique Dilatation des sillons du vermis et des hémispheres cerébelleux ainsi que du IVème ventricule dont le toit est arrondi par l atrophie sous-corticale Forte reduction de l épaisseur des lobules du vermis supérieur et de la région nodulo-amygdalienne

RÉSUMÉ

Les auteurs utilisent depuis 1958 une méthode pneumostratigraphique sagittale mediane de la fosse posterieure et rapportent des exemples qui demontrent l utilite de cette méthode Ils préconisent la généralisation de la pneumostratigraphie sagittale médiane comme premiere étape de toute encéphalographie gazeuse au niveau de la fosse postérieure

SUMMARY

The value of pneumostratigraphy, which has been employed since 1958, is illustrated by some examples. The authors suggest that the method be employed routinely as the first measure in the encephalographic examination of the posterior fossa region.

ZUSAMMENFASSUNG

Der Wert der Pneumostratigraphie, die seit 1958 angewendet wurde, wird an Hand von einigen Beispielen illustriert. Die Autoren empfehlen die Anwendung dieser Methode als erste Routine-Massnahme bei der encephalographischen Untersuchung des Gebietes der hinteren Schädelgrube.

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CINE ENCEPHALOGRAPHIC STUDIES UNDER NORMAL AND PATHOLOGICAL CONDITIONS

by

G B UDVARHELYI M W DONNER and R I TENNEY

This preliminary report describes a motion picture about roentgen intensification equipment as used at The Johns Hopkins Hospital for pneumoencephalography The operation of this unit is demonstrated during the first part of the picture and is followed by recordings of selected normal and pathologic air studies

The dynamical aspects of pneumoencephalography have been extensively studied during recent years but continuous observation of the air filling of the subarachnoid spaces and ventricular system could not be realized because of excessive radiation to the patient Modifications of the methods to demonstrate the different parts of the involved structures have been described by ROBERTSON (1957) LINDGREN (1949) BECKER & RATHKE (1941) BELLONI (1941) and GEILE & UDVARHELYI (1954) Terms such as fractional and directed encephalography reflect the effort which has been made to approach this aim

It became apparent that with the development of screen intensification, radiation could be sufficiently reduced to permit fluoroscopy during the air studies and even to record the procedure cinematographically Outstanding contributions in this field have been made by DECKER (1957) VERBIEST (1956) and WIEDENMANN & LEUCHS (1958) recognizing the prospect of the method



Fig. 1. Screen intensifier and image orthicon television system mounted above 180° tilt table. Viewing monitor and second monitor with 16 mm camera for cine recording are to the left.

Certain disadvantages, however, such as still relatively high dosage, particularly during cine recording, and limited facilities for instant viewing have been pointed out in various discussions. It is the purpose of this presentation to describe the use of The Johns Hopkins intensifier in pneumoencephalography, to discuss its advantages and to point out some of the difficulties inherent in the method.

As early as 1949 STURM & MORGAN (1949) and JANKER (1956) described the application of television in screen intensification. Since then this technique has been considerably improved and applied to various fields in diagnostic and therapeutic radiology. In neuroradiology its use in cerebral angiography, myelography, and pneumoencephalography appeared promising. Pilot studies were conducted in all three of these areas. The results of our studies in cine encephalography are discussed in the following pages.

Static roentgenograms — as single exposure or in series — have served to study anatomical alterations radiographically. The functional aspect of roentgen diagnosis has depended upon conventional fluoroscopy and its report of individual observations. In order to record these examinations on motion picture film, exposure factors delivering dosages which are incompatible with the radiation safety requirements were used experimentally but had to be abandoned as routine diagnostic methods for these reasons.

After screen intensification had become a practical reality, normal and pathologic conditions were explored recognizing its significance for early diagnosis. In pursuing this aim, the clinical application of intensifiers has become the technique of choice in the diagnostic evaluation in angiocardiography or an auxiliary method of investigation in the gastro-intestinal or genito-urinary fields.

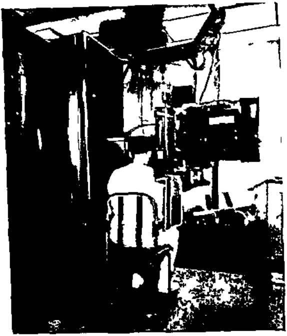


Fig 2 Patient in swivel chair for pneumencephalography positioned between intensifier and tilt table

In an attempt to examine the dynamics of fractional air filling in pneumo encephalography screen intensification was employed by means of the image orthicon television system of our hospital

The fluoroscopic image produced by an undertable roentgen tube is intensified by a 9 inch electron amplifier which is optically coupled to an image orthicon television system (Fig 1) Television camera and image tube are located above the 180 degree tilt table Cables transfer the resulting picture to two television monitors one for viewing and one for simultaneous cine recording A 16 mm motion picture camera is permanently mounted in front of the second monitor at a distance of 50 cm Rapid reversal film is exposed at a rate of 30 frames per second and hence synchronous to the frame rate of 30 cycles per second on the television apparatus Should immediate reviewing or further study be desired the examination can also be recorded on magnetic tape

The patient is seated on a swivel chair and brought between the roentgen table and the fluoroscopic screen (Fig 2) Following lumbar puncture an initial amount of 8 ml of air is slowly injected without fluid exchange while the patient s head is kept in a slightly flexed position The procedure continues with slow exchange of 2 to 3 ml of cerebrospinal fluid with air The air ascends in bubbles and fills the cisterna magna Its passage through the foramina of Magendie and Luschka into the fourth ventricle aqueduct and posterior third

ventricle occurs within seconds. Normally, 12 to 15 ml of air are sufficient to see air bubbles enter the lateral ventricles through the foramen of Monroe (Fig. 3). Simultaneous progressive filling of the basal cisterns is achieved under increased hyperextension of the head while flexion results in further filling of the lateral ventricles. Stereoscopic effect is obtained by rotating the head slowly along the vertical axis from the lateral into the posteroanterior position where flexion and extension will make it possible to demonstrate all parts of the lateral ventricles as well as the basal cisterns.

Pathologic conditions are demonstrated in a patient with diffuse cortical atrophy and in another one with suprasellar meningioma.

In cortical atrophy the air collects within the enlarged cisterna magna before it suddenly fills the fourth ventricle and spreads diffusely into the widened subarachnoid spaces. The dilated lateral ventricles show a long air fluid level and waves during motion of the head. Three dimensional viewing by rotating the patient's head will enable a demonstration of the relationship between ventricular and subarachnoid filling in an impressive fashion.

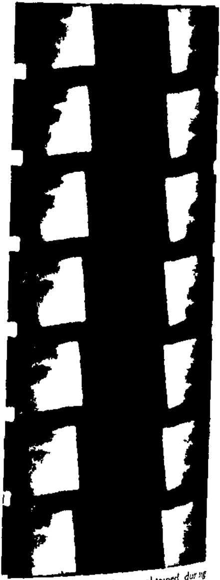


Fig. 3. Sequence of frames obtained during cine-encephalography demonstrates air bubbles passing through foramen of Monroe into lateral ventricles.

In a second patient with a large suprasellar meningioma, the following changes were observed. After normal passage of air through the fourth ventricle, aqueduct and posterior third ventricle into the lateral ventricles a delayed slow filling of the displaced prepontine cistern was seen. Hyperextension of the head showed obliteration of the chiasmatic cistern and slow advance of air in the interpeduncular cistern which was also displaced posteriorly by the tumor. Films taken during the various phases of the examination are very helpful in establishing a definite diagnosis.

Although a number of presentations and reports on cine encephalography have been made in the literature, it is felt that amplification utilizing television systems offer certain additional advantages which include

1 Easy simultaneous viewing by examining physicians and participating observers in normal daylight

2 Immediate step by step analysis and demonstration of anatomical structures the dynamics of the filling process, and pathologic conditions

3 Small radiation dose to patient and physician, the factors being 90 kV 1—2 mA maximum roentgen per minute 2 to 3 An automatic milliamperage control adjusts the roentgen ray intensity according to fields and patient thickness

4 Viewing of the examination by large groups at distant classrooms via closed circuit television

SUMMARY

The advantages of a continuous observation of the dynamics of encephalography and its documentation by cine recording for simultaneous and repeated viewing are commented upon The equipment used the various steps of the procedure and a few observations in normal and pathologic conditions respectively are briefly described

ZUSAMMENFASSUNG

Die Vorteile der fortlaufenden Kontrolle der Dynamik der Enzephalographie mittels Rontgenkinematographie werden besprochen Die notwendige Apparatur und die verschiedenen Phasen der Untersuchung werden beschrieben sowie einige Beobachtungen unter normalen und pathologischen Bedingungen

RESUME

Les auteurs commentent les avantages de l observation continue de la dynamique de l encephalographie et de son etude par enregistrement cinéradiographique pour examen répété et simultané Ils decrivent l appareillage utilisé les diverses phases de l examen et quelques cas normaux et pathologiques

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SOFT TISSUE MASSES IMMEDIATELY BELOW THE FORAMEN MAGNUM

by

INGMAR WICKBOM and WILLIAM HANAFEE

Encephalography performed in the way described by LINDGREN and by ROBERTSON makes it possible to examine not only the intracranial space but also the upper part of the spinal canal Not infrequently in this area a soft tissue mass may be seen lying dorsal to the spinal cord in patients whose symptoms indicate an intracranial lesion It may be due either to a tumor or to some parts of the brain that for some reason have moved down into the spinal canal A tumor in this area may have extended from the cranial cavity through the foramen magnum or it may have originated in the spinal canal itself Tonsils and part of the cerebellum may descend into the spinal canal either because of herniation or due to a malformation of the Arnold Chiari type

As it is of great importance to differentiate the soft tissue lesions in the upper cervical region and to find out how often changes of this type occur we have reviewed our encephalographic material

Material and Technique During the period 1953 to 1960 encephalographies were performed in 153 cases of posterior fossa lesions and 365 supratentorial expansive processes (see Table) The majority of the latter and some of the infratentorial tumors had been diagnosed solely by angiography, or the examinations had been made at other institutions these cases were not in

Table

Analysis of tumor cases that had encephalographies performed at Sahlgrenska Sjukhuset during the period 1953 to 1960 inclusive

Posterior fossa lesions	Number of cases	Tonsils depressed below foramen magnum	Tumor below foramen magnum
Arnold Chiari malformation type I	6	6	—
» II	1	1	—
» III	1	1	—
Cerebellar hemisphere tumors	36	22	3
Vermis	13	10	—
Fourth ventricle	18	—	
Pons and medulla	20	4	1
Pontine angle	23	7	1
Brain stem including aqueduct	12	1	—
Tentorium meningiomas	9	5	—
Others (cervical neuromas, granulomas, etc.	14	3	4
Total	153	60	16
Supratentorial expansive lesions	303	23	0

cluded in this material. The technique has been essentially the same during the period mentioned with only minor modifications, i.e. the one described by LINDGREN at an earlier symposium.

All our studies are with rare exceptions begun with lumbar encephalography. If the ventricles are not filled and if a study of the cisterns does not satisfactorily solve the problem, the examination is supplemented with ventriculography. Increased intracranial pressure and papilloedema are not considered contra-indications to encephalography by the lumbar route, if proper precautions are taken. In these instances parieto-occipital burrholes are made prior to the lumbar puncture. Only a few drops of fluid are allowed initially to escape from the needle to ensure good placement of the needle. The patient is carefully watched during the examination and if vital signs indicate an embarrassment, the lumbar needle is withdrawn and the patient is laid down. This will usually relieve the symptoms; if not, the ventricles are punctured for decompression. The patient has never failed to respond immediately, nor have there been any signs of permanent damage to the patient either in the roentgen department or on subsequent follow up in the hospital wards.

In the average patient, 8 ml of oxygen is injected by the lumbar route with the head in sharp forward flexion. The first film is a lateral view obtained with the roentgen beam centered on the foramen magnum. Proper centering is essential to minimize confusing superposition of such structures as the ear

and mastoid tip If the mastoids obscure this area, or if any soft tissue mass appears about the foramen magnum an autotomogram is taken according to the principles described by ZIEDSES DES PLANTES Generally, the first 8 ml will fill the cisterna magna vallecula, fourth ventricle and the aqueduct Patients with a large cisterna magna will require more gas The oxygen/cerebro spinal fluid exchange is continued until the inferior poles of the cerebellar tonsils are clearly outlined We always give at least twice as much oxygen as the amount of fluid removed The sharp forward flexion of the head usually permits the upper 2 to 3 cm of the cervical cord to be outlined We have lately by this method in every instance been able to identify the junction of the tonsils with the cerebellar hemispheres

Anatomy The cerebellar tonsils are paired and roughly rounded to pyramidal structures projecting from the posterior inferior margins of the cerebellum They lie in the cisterna magna and at encephalography can be sharply outlined by air The junction of tonsils with cerebellum is marked by a distinct notch along the posterior outline of the cerebellum, where the gas passes inferior to the vermis and between the cerebellar tonsils into the vallecula and foramen of Magendie (Fig 1) We have measured the vertical dimension of the tonsils from the notch to the inferior tonsillar pole, and in patients without posterior fossa disease it usually measured between 12 and 18 mm The inferior margins of the tonsils were either at, or slightly above the level of the bony margins of the foramen magnum They tend to lie at a higher level in children, making minor degrees of depression difficult to ascertain We believe that any tonsil lying below the level of the foramen magnum constitutes a pathologic state

Depressed tonsils due to tumor As may be observed from the Table posterior fossa lesions are prone to produce herniations Noting only the tumor cases, 52 out of 145 posterior fossa tumor cases had herniations The supratentorial lesions had a much lower incidence only 29 out of 365 cases However severe the herniation was air always entered the cranial cavity and depressed tonsils appeared to have little effect per se on the entry of gas or not into the ventricular system In about 40 % of the patients with tonsillar depression filling of the ventricular system was achieved at lumbar encephalography This is the same incidence of ventricular filling as observed in all cases of posterior fossa tumors

Herniated tonsils may vary in appearance from rounded configurations to flattened triangular outlines (Fig 2) In 69 out of 81 patients with depressed tonsils the tonsils were of the rounded shape while in the remaining 12 patients the tonsils varied from triangular to flattened shapes The diagnoses in the latter group were meningioma about the tentorium in 4 cases, parasagittal meningioma in 2 chronic granuloma in 2 cystic astrocytoma of the cerebellum in 3 and pontine glioma in 1 case



Fig. 1. Autotomogram obtained at lumbar encephalography after injection of 18 ml oxygen. The arrow points to the notch formed by the junction of the retrotonsular sulcus with the vallecula. Air is seen passing under the inferior vermis through the foramen of Magendie and into the fourth ventricle. The inferior margins of the tonsils lie at the level of the foramen magnum.

The difference in configuration of the tonsils is accompanied by a change in their overall length. The rounded type of herniation averages 20 mm in vertical height, as compared to 24 mm for the flattened type of herniation.

LILJEQUIST has made the same observation: the further down the tonsils extend the more pointed are their appearance, and conversely they are rounder and broader with lesser degree of downward displacement.

Arnold-Chiari malformations

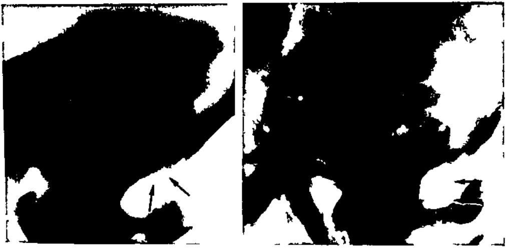
If CHIARI's classification, as quoted by OGRYZLO, is accepted, these malformations can be divided into three groups.

Type I. This is the mildest form of Arnold-Chiari malformation and only the tonsils are displaced into the cervical canal. By definition the fourth ventricle is entirely above the foramen magnum.

Type II. The tonsils, parts of the cerebellum, and parts of the fourth ventricle lie in the cervical canal.

Type III. A myelomeningocele is present in the upper cervical region containing the entire cerebellum.

A precise classification of patients with Arnold-Chiari malformation, atresia of the foramen of Magendie and Luschka, posterior fossa arachnoidal cyst, and syringomyelia is not always possible since considerable overlapping occurs in the pathologic anatomy of these entities. It is a frequently expressed opinion that in cases of Arnold-Chiari malformation the tonsils and the posterior fossa contents are pulled into the cervical canal by a meningocele or by



a b



c

Fig 2 a) Typical rounded acute herniation of the tonsils in a patient with a central infiltrating glioma Hemorrhages on the surfaces of the tonsils were seen at operation Even with such massive herniation gas always passes into the cranial cavity b) Triangular shape and (c) the flattened tongue like configuration of tonsils associated with slowly expanding intracranial processes Both were due to tentorial meningioma

arachnoidal adhesions According to GARDNER all are manifestations of the same embryologic defect i e failure of resorption of the primitive rhomboid roof he believes that such patients have persistent semipermeable membranes across the foramen of Magendie and Luschka If there is interference with the circulation of the cerebrospinal fluid prior to birth severe deformities with obstructive hydrocephalus may result Frequently the semipermeable membranes function well until adult life when some upset in the delicate balance of the cerebrospinal fluid dynamics occurs GARDNER states that this explains the delayed onset of symptoms and deformities in some patients

Type I We have had six cases of type I Arnold Chiari malformation all in adults Three were a mild form with triangular shaped tonsils and no hydro



a b

Fig. 3. Arnold Chiari malformation, mild type I, in a young woman. a) Head in forward flexion. The upper cervical air space is fairly large (arrows). b) Head in the erect position. The space becomes partially obliterated. The inferior margins of the tonsils move down to the level of C 1.

cephalus. Gas entered the ventricular system at lumbar encephalography. Other than the lowered position of the tonsils no additional deformities were present. The landmarks at the junction of tonsils with cerebellum were distinctly visible and normal. The remaining three were a more severe form of the type I Arnold Chiari state. Varying degrees of hydrocephalus were present and no air entered the ventricular system at encephalography. The tonsils were flattened elongated structures closely adherent to the cervical cord. The level of junction between tonsils and cerebellum could not be identified. The normal landmarks were smoothed out. Ventriculography revealed the fourth ventricle to be rather small and in a lowered position.

Type II. One baby showed a thickened soft tissue mass below the foramen magnum which appeared to be more than tonsils adherent to the cervical cord. Ventriculography in this case revealed the typical elongated extension of the fourth ventricle below the foramen magnum and into the region of this thickening (Fig. 5).

We had in addition 2 new born infants with marked hydrocephalus in whom the fourth ventricle extended slightly below the foramen magnum. At encephalography there was only a slight thickening of the soft tissue below the foramen magnum. We have not included these in our series because they are listed clinically as congenital atresias of the foramen of Magendie and Luschka. If one accepts GARDNER's definition of the Arnold Chiari malformation they could well be classified in the same group.



Fig 4 Rather severe type I Arnold Chiari malformation The flattened tonsils are indistinguishable from herniations produced by some of the slow growing tumors The fissures and notch are smoothed out by the long standing contact of the lower cerebellum and tonsils with the bony canal

Type III We had only one case of this type, in which the entire cerebellum lay in a large cervical myelomeningocele At encephalography, small bubbles of gas entered the myelomeningocele but no structures could be identified

Tumors

In 16 cases, the soft tissue mass below the foramen magnum proved to be a tumor Seven of the tumors originated as exophilic growths from the fourth ventricle As a general rule, they tended to grow in an orderly fashion, with sharply outlined lobulated margins The tumors left the fourth ventricle by spreading the tonsils and elevating both tonsils and vermis thus gaining access to the cisterna magna and the space below the foramen magnum Once in the cervical canal they extended for rather great distances, averaging 28 mm below the foramen magnum The distance from the 'notch' to the inferior pole of the soft tissue mass averaged 49 mm which was more than twice the length of an average normal tonsil (Fig 6)

Another type of fourth ventricular tumor grows in a voluminous and disorderly fashion totally destroying normal landmarks and almost completely filling the subarachnoidal cisterns Despite this in one of our cases ventricular filling was obtained which enabled us to make the diagnosis of a tumor originating in the fourth ventricle

Cerebellar hemispheric tumors may invade and replace a cerebellar tonsil so that practically no normal brain tissue remains Such a tumor mass readily gains access to the foramen magnum and acts like a herniated tonsil Three of our cases were of this type Because of the large bulk of the cerebellar hemispheric tumor the cisterna magna was compressed and the usual landmarks not visible

One of our pontine angle tumors had an unusually large inferior prolongation extending below the foramen magnum Otherwise it was a typical angle tumor that was very sharply outlined by gas

The remaining intracranial tumor that extended below the foramen



a b

Fig 5 Arnold Chiari malformation type II in a 1 year-old boy (a) Encephalography A soft tissue mass is seen behind the spinal cord with the lower pole at the lower margin of C1 (arrow) Gas does not enter the ventricular system (b) Ventriculography The elongated fourth ventricle (arrows) is displaced downwards into the cervical canal in the soft tissue mass seen in (a)

magnum was a pontine glioma It produced a localized thickening of the cervical cord by direct infiltration (Fig 7)

Four patients had tumors originating in the upper cervical region All were extramedullary (2 neuromas 1 dermoid and 1 hemangioendothelioma) They had a typical roentgen appearance partial arrest of gas below the inferior pole of the tumor The upper pole of the tumor could either be seen directly, or there was an air fluid level between the tumor and the tonsils (Fig 8)

Discussion

As already mentioned the tonsillar herniation due to coning may be of two types the rounded, and the flattened We believe that the difference in appearance is related to the duration of the herniation but to prove this repeat examinations at various intervals would be necessary and this is not feasible



Fig 6 Typical extension of a 4th ventricle tumor (ependymoma) below the foramen magnum Notch (←) and tonsils are displaced posteriorly and slightly elevated The tumor (↔) extends to the lower margin of the arch of C 1 Only chronic tonsillar herniations would extend so far below the foramen magnum and then one would expect a more flattened configuration



Fig 7 Infiltration of the upper cervical cord by a pontine glioma (arrows) Investigation of the ventricular system and the posterior fossa cisterns is necessary for demonstrating the intracranial origin of a tumor In this case gas entered the ventricular system at encephalography and ventriculography was therefore not necessary

We have however only seen the flattened type with slowly growing tumors while on the other extreme the rapidly growing tumors invariably produce the rounded type of tonsils Some of our more slowly growing lesions also had the rounded type of herniation But this does not necessarily disprove our hypothesis Clinically it is a wellknown fact that some benign tumors remain silent for relatively long periods The herniation of tonsils may be just beginning at the time of the roentgen examination and may or may not be accompanied by a recent exacerbation of symptoms

It is only natural that the flattened type should accompany a chronic process The tonsils have had more time to accommodate to the space available The moulding effect of flexion and extention of the head causes the tonsils to be flattened by the bony spinal canal (Fig 3)

The rounded types of herniated tonsils do not as a rule present any diagnostic difficulties if they measure less than 25 mm in vertical diameter Cerebellar tumors infiltrating the tonsils and then herniating could conceivably cause confusion but these tumors generally descend to a much lower level The cisterna magna also becomes compressed by the large bulk of hemisphere tumors

The flattened type of tonsil herniations associated with slowly growing tumors have an appearance similar to the tonsils in Arnold Chiari malforma



Fig 8 Neuroma at the level of C 1—C 2 in a 14 year-old girl The gas *is somewhat* arrested below the tumor but even then the *upper pole is* outlined (arrows

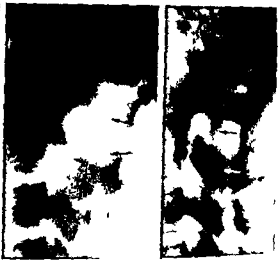


Fig 9 Hydromyelia in upper part of cervical cord in a 42 year-old woman *Left* Gas myelography The patient was lying with the head lowered and the spinal canal drained as much as possible by cisternal puncture *Right* Encephalography The patient was sitting erect with sharp forward flexion of the head Gas was injected by the lumbar route The upper part of the cervical cord is much thicker in the myelogram probably due to difference in hydrostatic pressure This proves that the mass is not a solid tumor but a cavity containing fluid

tion The latter group, usually being a more longstanding process tends to cause a more marked flattening of the tonsils This is only a matter of gradation and considerable overlapping exists In the individual cases, it may therefore be impossible to distinguish the lesions from the appearance of the tonsils alone and extreme care should be taken to search for other signs of an intracranial tumor

To grade the Arnold Chiari malformation the fourth ventricle must be filled with contrast In the more severe cases gas rarely enters the ventricular system at encephalography, and ventriculography becomes necessary

Tumors from the fourth ventricle and pons tend to displace the tonsils upwards in the cisterna magna, rather than to depress them below the foramen magnum In cases where the cisterna magna is compressed, and the tonsils cannot be outlined, other evidence must be sought Tumors growing from the fourth ventricle have a more irregular outline than tonsils Another evidence may be found by demonstrating the fourth ventricle and showing the primary site of origin, only exceptionally can this be accomplished with encephalography

Pontine or brain stem tumors, infiltrating downwards, may be similar in appearance to a spinal cord tumor These tumors also produce characteristic

displacements of the fourth ventricle and aqueduct however, as well as compression of the cisterns in the posterior fossa If gas does not enter the ventricular system at encephalography, ventriculography may become necessary for establishing a definite diagnosis

Hydromyelia of the cervical cord may also simulate tumor infiltration If the thickened cord can be shown to be compressible as occurred in some of our cases, this is proof that the lesion is not a solid tumor (Fig 7) If in addition the Arnold Chiari type tonsils are present, this is further evidence of hydromyelia

Tumors originating in the upper cervical region should not as a rule cause any great diagnostic problems If air passes the tumor at encephalography, it should be possible to outline the upper border as well as the lower limit of the lesion With these tumors, the problem is not generally one of differentiation but rather not to overlook the presence of a tumor

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SUMMARY

Encephalography of the upper cervical region is of particular value in cases of lesions situated primarily about and just below the foramen magnum Such lesions cause similar symptoms to those of intracranial processes and may otherwise be overlooked A study of the soft tissue masses about the foramen magnum is frequently of great help for the establishment of a definite diagnosis and knowledge of the extension of intracranial tumors below the foramen magnum is of value whether treatment will be with surgery or radiation therapy

ZUSAMMENFASSUNG

Encephalographie der oberen Zervikalregion ist von besonderem Werte bei den Fallen bei denen die Lasionen primar um das Foramen magnum herum oder etwas unterhalb davon gelegen sind Solche Prozesse verursachen ahnliche Symptome wie intrakranielle Prozesse und konnen leicht ubersehen werden Eine Weichteilstudie in der Gegend des Foramen magnum ist fur die Stellung einer definitiven Diagnoze oft von grosser Hilfe und die Kenntnis der Ausbreitung intrakranieller Tumore unterhalb des Foramen magnum von grossem Wert unabhangig davon ob die Behandlung chirurgisch oder radiumterapeutisch ist

RÉSUME

L encéphalographie de la région cervicale superieure présente un interêt particulier dans les cas de lésions situées primitivement près et immédiatement au dessous du trou occipital Ces lésions donnent des signes semblables à ceux que donnent les lésions intracraniennes et peuvent en l absence de cet examen rester méconnues L étude des masses de tissus mous au voisinage du trou occipital est souvent d un grand secours pour établir un diagnostic précis et il est important de connaitre l extension des tumeurs intracraniennes au dessous du trou occipital que le traitement doive etre chirurgical ou radiothérapique

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FROM THE NEUROSURGICAL DEPARTMENT (DIRECTOR PROF KR KRISTIANSEN) AND THE ROENTGEN DEPARTMENT (DIRECTOR PROF J FRIMANN DAHL) ULLEVAL HOSPITAL, OSLO, NORWAY

EVALUATION OF LUMBAR RADICULOGRAPHY ('MYELOGRAPHY') WITH WATER SOLUBLE CONTRAST MEDIA

by

PER AMUNDSEN, PER HELSINGEN and KRISTIAN KRISTIANSEN

ARNELL & LIDSTROM (1931) were the first to use the contrast medium Abrodil in the examination of the spinal canal, a method that was termed Abrodil myelography or myelography with water soluble contrast (ARNELL 1948) Because of the irritation caused by this type of contrast medium this method must however be limited to the examination of the lower part of the dural sac with the cauda equina for which the term radiculography that is used in the French literature is certainly more correct (BETOULIERES TEMPLE & JANICOT 1960) The superb roentgenologic definition of the root sheath that is obtained with water soluble contrast media constitutes an important difference between this method and myelography with iodized oils Despite the fact that this type of examination has become a routine procedure in Scandinavian countries as well as in certain European centres (REINHARDT & PANTER 1955 FASSBENDER HAUSSLER & STOSSEL 1958 VIGNON MEGARD DURANT CALVEL, DUQUESNEL 1960) it has not been universally accepted This has apparently been due to the reports of complications dating back to the earliest period of trial complications that may easily be avoided (LINDBLOM 1947 DENSTAD 1949 LINDGREN 1954)

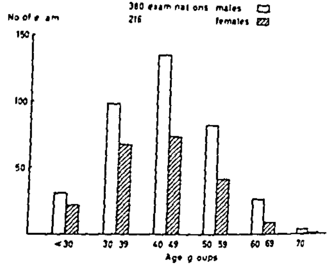
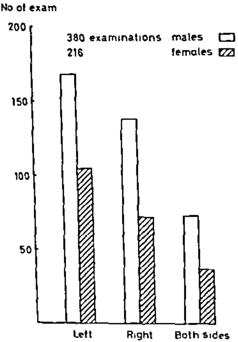


Fig. 1 Age and sex distribution in the material

The investigations now reported were planned to provide exact data for an evaluation of the diagnostic merits of the procedure and to collect evidence on the safety of the method in a department where the same technique has been applied for 13 years

Material Five hundred and ninety six examinations were performed in a total of 517 cases from the beginning of 1955 to the middle of 1960 There were 328 males, subjected to 380 examinations and 189 females subjected to 216 examinations thus nearly twice as many males as females The majority of the patients were in the period of life of high activity and work, with re markable peak in the 40—49 years group (Fig 1) This applied to both sexe The side examined (Fig 2) was chosen according to the symptoms and signs There was a certain predominance of left sided lesions in both sexes which is in accordance with the experience of other investigators Both sides were examined at the same sitting in about 20 per cent of the examinations

Technique The technique employed in our department is largely that described by LINDBLOM (1946 1950) This author stressed the importance of using a fine needle The patient must be kept quiet and relaxed during the examination to prevent an admixture of the contrast medium and spinal fluid any active participation by the patient is avoided and he is positioned by a specially trained technician Following the examination the patient is kept in the roentgen department for an hour lying prone on the tilting table with the upper part of the body elevated so as not to be moved until most of the contrast medium has been absorbed (Fig 3)



F g 2 D agram showing wh ch sides were exam ined

It is essential, as LINDBLOM (1946) pointed out to use a horizontal beam A special tilting table that can be plac ed in a screening stand is employed so that accurate centering and coning is obtained (Fig 4) Spinal anaesthesia is secured with 0 10 g procaine and 0 005 g tetracaine dissolved in 2 ml spinal fluid, and 10 minutes later 10 ml Mye lotrast (Abrodil) 20 % are slowly inject ed over a period of 2 minutes

Method of investigation All the radic ulograms were re examined by a neurosurgeon and a neuroradiologist together Care was taken to mask the names on the films in order to pre vent either of the two examiners re membering the case The clinical and pathologic data including the opera tion reports and the follow up exami nations of each case, were re evaluated from the notes by another neurosurgeon The clinical notes were not avail able in a few cases and these have been omitted from the correlation study

Five hundred and twelve of the radiculographies were classified as perfect 56 as less satisfactory but still diagnostic, and 22 or less than 5 % were regarded as not being of diagnostic value

The diagnostically useful upper level of the contrast medium lay at L 2 in the majority of the cases (Fig 5) Contrast filling up to Th 11 with oblitera tion of the distal part of the dural sac due to complete obstruction from a herniated disk postoperative changes or tumours was noted in a few cases Even in these cases no bad effects were observed and we feel that this is due to the very slow rate at which both the spinal anaesthetic and the contrast medium are injected

Complications and side effects Minor side effects such as headache or moderate transitory pain in the legs may escape attention in a retrospective survey but no serious complications were recorded in our material A fall of blood pres sure and signs of collapse 2 hours after the examination with rapid response to 0 05 g ephedrine subcutaneously were noted in one case

Some of the contrast medium had been deposited subdurally in 12 cases but no subsequent complications were observed A considerable increase in

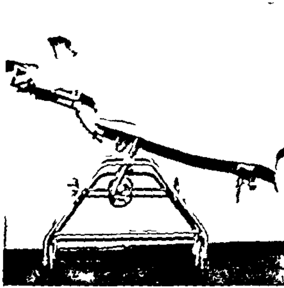


Fig. 3. Patient recumbent on tilting table after the examination.

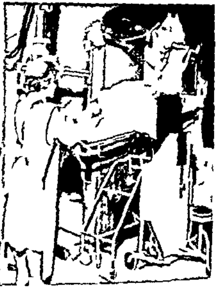


Fig. 4. Patient recumbent on tilting table arranged for screening. Centering and coning are effected during fluoroscopy.

the protein content with or without an increase in the number of cells in the spinal fluid was found before the examination in 41 cases but again no untoward sequelae were recorded.

Table 1

Radiologic review diagnoses in the material studied

		Males	Females	Total	
Disk herniations	Definite	101	64	165	249
	Probable	22	7	29	
	Possible	34	21	55	
No disk herniation	Negative	129	74	203	319
	Other lesions	71	45	116	

Table 2

Correlation of positive radiologic review diagnoses to clinical re-evaluation

Radiologic review	Clinical re-evaluation: Herniated disks		Clinical re-evaluation: No herniation clinically	Total
	Operated	Clinically		
Definite disk herniation	121	39	5	165
Probable disk herniation	16	13	—	29
Possible disk herniation	22	27	6	55
Total	159	79	11	249

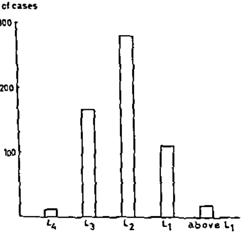


Fig 5 Upper diagnostic levels of the contrast columns

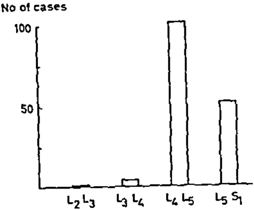


Fig 6 Disk lesions at the different levels encou nt red in a material of 159 cases

Results

Each examination was placed in one of two groups disk herniation or no disk herniation (Table 1) Disk herniations were labelled definite if the roentgenologic diagnosis was certain If the signs were less marked but there was a slight impression in the dural sac and affection of one or more roots the case was placed under the heading probable herniation Minor changes such as a short thickened root sheath were classified as possible herniation The group no herniation was divided into two sub groups one consisting of no pathologic changes designated negative and one with other patho logic changes that included conditions such as postoperative changes tumors root cysts etc

Two hundred and forty nine examinations were considered to indicate the presence of herniated disk The number of 'probable herniations proved to be small and comprised only about 10 % of the whole group This fact in dicates that signs of impressions in the dural sac and of the presence of af fected roots rarely leave any doubt regarding the causal agent The diagnosis in the 55 examinations grouped as possible disk herniation must be regarded as questionable

Only 5 of the 194 cases diagnosed as definite or probable disk lesions may be regarded as false positive diagnoses since no clinical evidence of a disk

Table 3

Correlation of the negative radiologic review diagnoses to clinical re-evaluation

Radiologic review	Clinical re-evaluation			Total
	Herniated disks		No herniation	
	Operated	Clinically	clinically	
Negative	16	82	105	203
Other lesions	18	27	71	116
Totals	34	109	176	319

lesion was detected (Table 2). Six such false positive diagnoses were apparent in the 55 examinations roentgenologically classified as possible disk herniation.

Sixteen false negative diagnoses were disclosed at operation among the 203 cases diagnosed as negative on review (Table 3). A disk lesion was diagnosed clinically in 82 cases but, since these had not been operated upon, these cases cannot be regarded as false negative. The incidence of operated disk herniations (false negative diagnoses) is somewhat higher (18 out of 116 cases) in the group "other lesions" than in the group considered roentgenologically negative.

The level of the disk lesion diagnosed roentgenologically could be compared with the findings at operation in 159 cases (Fig. 6). In 9 of these operation revealed a herniated disk at a level other than the one predicted by the radiculography. The majority of these cases had transitional vertebrae at the level of which a disk lesion had erroneously been diagnosed.

Complete agreement was evident between the original and the review diagnoses, including the 5 false positives in the groups diagnosed in the survey as "definite" or "probable disk herniation" (Cf. Table 2). The roentgenologic appearances in these cases are obviously so impressive that the diagnosis will not be influenced by the clinical picture. On the other hand the original diagnoses included only 1 of the 6 false positive diagnoses in the group "possible disk herniation" and only 3 false negative diagnoses as compared to 16 in the review (Cf. Table 3), indicating that the evaluation is apt to become biased when the roentgenologic signs are doubtful.

SUMMARY

Five hundred and ninety six lumbar myelographies (radiculographies) in 5[illegible]7 cases are reviewed and the results correlated with the clinical data. The incidence of a false positive diagnosis was less than 3 %, but in 16 of the 203 cases grouped as radiologically negative a herniated disk was disclosed at operation. No major complications following the examination were observed.

ZUSAMMENFASSUNG

Die 596 lumbalen Myelographien (Radikulographien) die an 517 Fallen vorgenommen wurden werden besprochen und mit den klinischen Befunden verglichen Nur 3 % der Falle gaben falsche positive Resultate und 16 von 203 Fallen die rontgenologisch negativ waren hatten in der Tat einen Diskprolaps Schwerere Komplikationen wurden nicht beobachtet

RÉSUMÉ

Les auteurs ont passé en revue 596 myélographies lombaires (radiculographies) dans 517 cas et en ont confronté les résultats avec les signes cliniques La fréquence des diagnostics faussement positifs a été inférieure a 3 % mais dans 16 des 203 cas considérés comme radiologiquement négatifs on trouva a l intervention une hernie discale Cet examen n a pas été suivi de complications graves

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DIAGNOSTIC DES MYÉLOPATHIES CERVICALES D'ORIGINE DISCALE PAR LA MYÉLOTOMOGRAPHIE GAZEUSE PAR VOIE LOMBAIRE

par

G. BONTE et C. DELFOSSE

Il est généralement admis que les hernies et protrusions discales intrarachidiennes cervicales occasionnent des microtraumatismes répétés sur les vaisseaux du sillon antérieur de la moelle finissant par entraîner une ischémie dans le territoire de l'artère spinale antérieure. La saillie intrarachidienne des ligaments jaunes lors des mouvements d'hyperextension du cou participe indirectement à ce mécanisme en refoulant la moelle contre les disques protrus. Les ligaments dentelés latéraux enfin fixent la moelle qui ne peut fuir devant le processus discal expansif.

Initialement traitées avec des résultats médiocres par ablation directe, les hernies et protrusions discales cervicales sont actuellement curables par traitement chirurgical indirect : laminectomie associée à la dentellectomie qui, libérant la moelle, donnent d'excellents résultats. Encore faut-il que le traitement chirurgical soit décidé avant l'installation des lésions de myélomalacie ischémique irréductible. Un diagnostic précoce s'impose donc d'une façon absolue.

La symptomatologie clinique de la discarthrose se manifeste généralement entre 40 et 50 ans, apparaissant chez des sujets plus jeunes elle correspond à

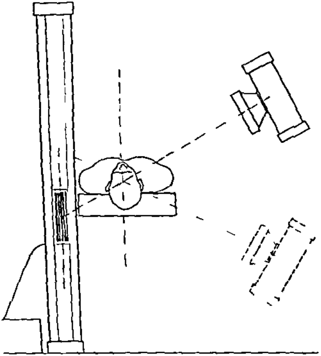


Fig 1 Schema technique Le malade est disposé en décubitus dorsal sur une table annexe devant le tomographe à balayage lineaire vertical L alignement du rachis dans un plan parallèle à celui du tomographe est facilement realise L utilisation d une cassette à 5 films regulièrement espacés de 2 5 mm permet l obtention d une tomographie simultanee de tout le canal rachidien

une discarthrose localisee secondaire a un traumatisme plus ou moins meconnu Elle debute par des troubles moteurs ou des troubles sensitifs plus rarement par des troubles du tonus ou des troubles de la sensibilite Le tableau clinique se complete en quelques mois ou en plusieurs annees pour realiser des formes extremement polymorphes soit a predominance motrice soit a predominance sensitive soit plus rarement sous forme de syndrome de BROWN SEQUARD ou d un syndrome classique de compression medullaire Assez souvent le tableau clinique evoque une sclerose laterale amyotrophique, une sclerose en plaques ou une poliomyelite anterieure chronique Tous les intermediaires se retrouvent donc entre la simple radiculalgie et la myélopathie majeure

Devant une symptomatologie si diverse la radiographie standard du rachis cervical indispensable n apportera jamais d élement absolu, d autant qu existe une discordance complete entre les manifestations pathologiques et les lesions anatomiques le mecanisme vasculaire en effet explique dans une certaine mesure que des cervicarthroses severes puissent rester neurologiquement muettes pourvu que les vaisseaux spinaux anterieurs echappent a la compres

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La symptomatologie clinique de la discarthrose se manifeste généralement entre 40 et 50 ans apparaissant chez des sujets plus jeunes elle correspond a



Fig 3 Jonction cervico-dorsale normale La jonction cervico-dorsale est obtenue en dissociant les masses scapulaires (position du nageur de crawl) La radiotransparence relative du rachis cervical est compensee par un filtre en biseau de 2 cm d aluminium dispose sur le diaphragme à la hauteur du cou du sujet

inspiree de celle de MURTAGH et coll, nous semble cependant presenter des avantages de facilite pour l operateur de confort et d innocuite pour le malade qui nous la font preferer aux autres tout au moins pour la recherche particuliere des myélopathies par cervicarthrose elle consiste a rassembler dans le siphon cervical 30 a 50 ml de gaz introduits par ponction lombaire Le malade confortablement dispose en decubitus dorsal sur une table annexe articulee est amene devant un tomographe a balayage lineaire vertical Le parallelisme entre le plan des films et le plan du rachis cervical est facilement obtenu I utilisation d une cassette contenant cinq films espaces de 2 5 mm donne la certitude de l obtention simultanee d une ou plusieurs radiographies parfaites tout en diminuant l irradiation du sujet Le numerotage des cliches tomographiques permet de juger de l expansion laté rale de la discopathie Le balayage tomographique vertical perpendiculaire a l axe du rachis donne un effacement transversal des apophyses articulaires et elimine ainsi les trainees pseudo medullaires occasionnees par l effacement longitudinal de celles ci (Figs 1 et 4)

La region cervicale inferieure et dorsale superieure est degagée de la projection des masses scapulaires en relevant un des bras du sujet (position du nageur de crawl) et en compensant la radio transparence relative du rachis cervical par un filtre en biseau de 2 cm d aluminium disposé sur le tube a la hauteur du cou du sujet (Fig 3)

La position du sujet en decubitus l hyperextension du cou accolent le cordon medullaire en arriere contre le ligament jaune La lame gazeuse occupe l espace compris entre la moelle en arriere et la gaine durable en avant



Fig 4 Pneumomyélotomographie simultanée En un seul balayage une etude complète des éléments inclus dans le canal rachidien est réalisée Les plans medians et paramédians montrent les disques cervicaux moyens protrus au contact du cordon médullaire légèrement déprimé sur sa face anterieure en C —C6

Celle ci double le bord postérieur des corps vertébraux et des disques, dont elle reflètera fidèlement les expansions posterieures A l état normal les contours antérieurs du cordon médullaire dessinent un arc parfait, et aucun espace libre n est bien défini par le gaz en arrière de la moelle (Fig 2) L espace libre prémédullaire n est pas de dimensions fixes par suite des variations constitutionnelles tres grandes du diametre antéro postérieur du canal rachidien Ce phénomene explique dans une certaine mesure que certaines moelles à l etroit souffrent plus de petites protrusions que d autres, libres dans un canal plus vaste

L analyse des cliches myélographiques permettra par conséquent de distinguer les lésions du contenant (protrusions et hernies discales, alterations du tissu épidural et des corps vertébraux) et les lesions du contenu (cordon médullaire essentiellement dans le cas de la pneumomyélographie)

La classification radiologique des hernies et protrusions discales postérieures rejoint la classification anatomique de ces lésions On distingue classiquement deux types de lésions discales cervicales

Hernie discale realisée lorsque le noyau gélatineux fait saillie a travers les fibres dechirees de l anneau fibreux sous le ligament longitudinal postérieur (hernie intraspinale) ou à l intérieur du trou de conjugaison (hernie uncovertébrale) ces dernieres echappent a la myélographie La hernie est essentiellement la complication d un traumatisme violent et se rencontre chez le sujet jeune car elle nécessite pour se produire un nucléus bien hydraté (BEADLE)

Protrusions de l anneau fibreux, d ordinaire globales et localisées a plusieurs interlignes cervicaux moyens et inférieurs sont beaucoup plus fréquentes elles



Fig 5 Protrusion discal unisegmentaire post traumatiqu La saill e posterieure du plateau inferieur de C3 prolongee de la p otrusion d scale agresse fortement la moelle qui est dé p imée et atrophiee vis à vis d la les on spondylodiscale



Fig 6 Protrusions discales étagées de petit volume Les protrusions sont très discrètes le canal est etroit Le cal bre de la moelle est normal et ses contours restent réguliers

se manifestent en effet lorsque les disques s affaissent par dessiccation de leur noyau

En fait FRYKHOLM fait observer qu hormis le cas de hernie discale pure survenue a la suite d un effort brutal chez un sujet jeune, la différenciation entre hernie et protrusion est souvent impossible cette derniere peut etre limitee et unisegmentaire, alors qu une hernie peut subir des appositions de tissu osseux de neoformation

La pneumomyélographie n en est pas moins d un grand interet pour le diagnostic topographique de hernie pure post traumatique car les radio graphies standard peuvent ne s'accompagner que d un pincement uniseg mentaire discret ou meme ne se traduire par aucune alteration apparente de l interligne Ces lesions jeunes sont peut etre les seules qui restent susceptibles d un traitement chirurgical direct plus tardivement leur technique thera peutique ne se distingue pas de celle des protrusions (Fig 5)

Le plus souvent etagees a plusieurs espaces cervicaux, C4—C5 a C6—C7 les protrusions discales sont de volume variable Elles se marquent sur la face antérieure du sac dural realisant une ombre festonnee tres caractéristique doublant le contour osseux Les disques protrus soulevent le ligament longitu dinal posterieur le tissu epidural sous jacent s épaissit de maniere parfois



Fig 7 Moell à l etroit Le calibre medullaire est normal les interlignes spondylodiscaux sont tous bien définis Par suit d l etroitesse congénital du diamètre antero-posterieur du canal rachidien des protrusions même discrètes comprimeront immediatement la moell ou les vaisseaux spinaux anterieur



Fig 8 Protrusions discales C4—C5 et C5 C6 Les protrusions discal sont volumineuses Les contours anterieurs de la moell sont d primés en face d ces protrusions

tres importante participant a la compression medullaire l espace libre premedullaire est parfois reduit a une lame presque virtuelle interrompue a la hauteur de chaque interligne par les protrusions discales (Figs 6 et 8 Nous avons dit que les troubles etaient accentues lorsque le cordon médullaire etait a l etroit dans un canal rachidien congenitalement peu large (Fig 7

Le retentissement anatomique des protrusions sur la moelle portant le pronostic de l affection, est tout particulierement demontré par la pneumomyelographie d abord de calibre important et partout egal, de contours antérieurs régulierement arques malgré les protrusions discales qui viennent a son contact, la myelomalacie ischemique va progressivement entrainer une reduction du calibre medullaire, un festonnement des contours anterieurs de la moelle, deprimee a la hauteur de chaque disque protrus Un bon signe d atrophie medullaire est apporté par la presence d une large bande gazeuse derriere la moelle, ce qui ne se voit jamais chez le sujet normal en position d hyperextension du cou Le pronostic, lorsque sont apparues ces manifestations irreductibles de myelomalacie, est sombre tout au plus est il permis d espérer



Fig 9



Fig 10

Fig 9 Protrusion discale C6—C7 unisegmentaire Le plan myelotomographique de la jonction cervico-dorsale objective une protrusion postérieure moyenne unisegmentaire A ce niveau le cordon médullaire présente des contours antérieurs légèrement deprimés

Fig 10 Pneumomyelographie pre et post-opératoire L étude myélotomograph que initiale montre de volumineuses protrusions discales étagees La laminectomie associée à la dentellectomie libère la moelle et les racines cervicales inférieures chez ce malade qui présentait un syndrome d Aran Duchenne

par dentellectomie et laminectomie une stabilisation des troubles (Figs 9 et 10)

La bénignite absolue de la pneumomyélographie permet d effectuer sans risque pour le malade un controle post operatoire la récuperation d un espace premedullaire large — la moelle gardant un calibre normal et des contours réguliers — permet d espérer une récupération fonctionnelle totale Des réserves sont a faire lorsque la moelle, bien que libérée presente des signes radiologiques d atrophie grave

RÉSUMÉ

Pour l étude des retentissements médullaires des cervicarthroses qu il importe de détecter au debut dans le but d une intervention chirurgicale efficace les auteurs donnent leur préférence à la myélographie gazeuse méthode d une innocuité absolue L injection est effectuée par voie lombaire les clichés sont pris en décubitus dorsal en utilisant la tomographie simultanée qui assure l obtention rapide de radiographies parfaites ou sont parfaitement définis le volume et les contours du cordon médullaire ainsi que les modifications des tissus mous épiduraux pré médullaires et la situation des disques



Fig 7 Moelle à l étroit Le calibre médullaire est normal les interlignes spondylodiscaux sont tous bien définis Par suite de l étroitesse congénitale du diamètre antéro postérieur du canal rachidien des protrusions même discretes comprimeront immédiatement la moelle ou les vaisseaux spinaux antérieurs



Fig 8 Protrusions discales C4-C5 et C5-C6 Les protrusions discales sont volumineuses Les contours antérieurs de la moelle sont déprimés en face de ces protrusions

tres importante participant a la compression medullaire l espace libre premedullaire est parfois reduit a une lame presque virtuelle interrompue a la hauteur de chaque interligne par les protrusions discales (Figs 6 et 8) Nous avons dit que les troubles etaient accentues lorsque le cordon medullaire etait a l etroit dans un canal rachidien congénitalement peu large (Fig 7)

Le retentissement anatomique des protrusions sur la moelle portant le pronostic de l affection, est tout particulierement démontré par la pneumomyelographie d abord de calibre important et partout égal, de contours anterieurs regulierement arques malgré les protrusions discales qui viennent a son contact, la myélomalacie ischémique va progressivement entrainer une reduction du calibre médullaire, un festonnement des contours antérieurs de la moelle, déprimée a la hauteur de chaque disque protrus Un bon signe d atrophie médullaire est apporte par la présence d une large bande gazeuse derriere la moelle, ce qui ne se voit jamais chez le sujet normal en position d hyperextension du cou Le pronostic, lorsque sont apparues ces manifestations irreductibles de myelomalacie est sombre tout au plus est il permis d esperer

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CERVICAL DISCOGRAPHY

by

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Discography is the roentgenographic demonstration of an intervertebral disc by injection of a contrast medium into the disc This diagnostic roent genographic procedure is not new, having been first introduced fourteen years ago It was then used in the lumbar region but in the cervical region the method has only recently been applied The cervical disc is punctured on its antero lateral surface The information obtained from this procedure has led to a more complete understanding of the pathologic origin of neck shoulder and arm pain and has been primarily responsible for the introduction of a new surgical technique for the treatment of lesions of the cervical spine by an anterior approach The indication for these new surgical procedures is almost entirely dependent upon cervical discography for preoperative roentgeno graphic diagnosis

The writer s experience with cervical discography covering a period of 7 years and a series of over 400 cases, is reported in the present paper Some of the material has been described in previous publications and will be only briefly reviewed the reader is referred to the original articles (CLOWARD 1958, 1959 1960)

In their classical monograph on studies of the intervertebral discs published in 1932 SCHMORL and JUNGHANS injected dyes and opaque substances such a

red lead into the nucleus pulposus for roentgenographic and photographic demonstration of the intervertebral discs in cadavers and specimens A clinical diagnostic procedure was described by LINDBLOM (1948), transdural puncture in the sagittal plane by ERLACKER (1949) and extradural puncture by DE SEZE & LEVERNIEUX (1951) Lumbar discography has been of inestimable value in the clinical diagnosis of an internal rupture of an intervertebral disc following injury as a cause for low back pain with or without sciatica (CLOWARD 1953)

Cervical discography, according to a recent publication by SMITH (1959 was first performed by him in 1952 His early work however was not published My introduction to discography has been attributed to Dr Exum Walker of Atlanta, Georgia, who showed me a cervical discogram in February 19– Over the subsequent two years, experimental and clinical experience with the procedure preceded publication of the initial description of the technique of cervical discography (CLOWARD 1958) Since that time, numerous authors have added their experience to the literature including SMITH (1959) CLOWARD (1959) and STUCK (1961)

Technique

Cervical discography is preferably performed in the roentgen department with the patient on a customary roentgen table or a Guerney Two roentgen units are employed The patient's head neck and shoulders are placed on a special box designed for this procedure which is equipped with a tunnel beneath and a slot on the left side to hold the cassettes for the antero-posterior and lateral projections respectively

The instruments to be used are previously prepared on a sterile tray with antiseptic solutions ampoules of 1 % procaine or xylocaine hypodermic needles, a 2 ml syringe a Luer Lok 1 ml tuberculin syringe for injecting the discs 1 ml ampoules of a Hypaque 50 % solution 1 ml ampoule of sterile methylene blue dye and two sets of needles each including a two inch No 20 and a two and a half inch No 25 B & D needle

The patient is prepared with a mild analgesic prior to the procedure should it be excessively painful The head is placed in slight extension by means of a triangular plastic sponge cushion beneath the patient's neck on the box (Fig 1) The right half of the neck is prepared with antiseptic solutions and the skin and superficial muscles are infiltrated with local anesthesia The C5-6 disc is always investigated first, as lesions at this level make up over 60 % of pathologic discs The operator's index and middle finger is placed in a vertical position opposite the cricoid cartilage along the medial border of the sternomastoid muscle and deep pressure is exerted on the goove between the larynx and the carotid artery (Fig 2) The carotid pulsations should be felt on the ball of the fingers Further displacement of the larynx and esophagus and deeper digital pressure will bring the finger tips in contact with the anterior surface of the spine The ridges of the intervertebral discs can often be palpated in slender necks Should the deep pressure be disagreeable to the patient the hyponeedle is inserted to contact bone, and a local anesthetic injected onto the surface of the spine and the injection continued as the needle is slowly withdrawn

A two-needle technique is strongly recommended for percutaneous cervical disc injection The initial puncture is made with a No 20 gauge needle 5 cm long attached to a 2 ml syringe which is used as a handle The fingers are pressed firmly against the spine displacing the larynx and esophagus as far to the left as possible The guide needle held in a vertical position is passed through the skin between the pressing fingers The needle will make contact with



Fig 1 Patient in position on cervical box for discography using two roentgen tubes

the spine (or the disc) often at a depth of less than one centimeter If the needle contacts bone short jabs are made up and down the spine until the soft anterior surface of the disc is encountered The finger tip pressure is maintained on either side of the needle during the probing When the disc has been located the guide needle is pressed into its anterior fibers a distance of not more than 2 millimeters When the finger pressure is released the displaced larynx will assume its normal midline position and the vertically placed guide needle will form a 45 degree angle with the long axis of the spine The needle is held in this position the tissue of the neck pulled up around it and the fine needle inserted into it

The 25 gauge fine needle 6 5 cm long passes through the outer disc fibers and into the nucleus pulposus The patient is cautioned not to swallow talk or move while preliminary roentgenograms are obtained to determine the location and position of the needle point prior to injection Recent use of a polaroid roentgen unit in which a preliminary positive roentgenogram can be obtained in 10 seconds has been exceedingly valuable in shortening the time required to complete the examination

When the preliminary roentgenograms demonstrate the point of the fine needle to be in the center of the intervertebral space (in both a p and lateral projections) the contrast medium is injected A 50 % iodized aqueous solution is required for the roentgenographic demonstration of the small quantity of contrast medium that a normal cervical nucleus pulposus will accept Considerable force may be needed to inject the medium particularly in a normal disc and for this reason a small Luer Lok syringe is valuable to prevent the syringe from slipping off the needle

While the films are being developed the needle is held in position by the operator and the patient having been cautioned that the injection may cause pain is asked to describe its exact nature and location This information is recorded along with the roentgenographic findings If the clinical symptoms are reproduced by the injection and the radiologic findings correspond with the clinically suspected lesion the disc is marked for surgical treatment with methylene blue dye prior to withdrawal of the needles A small amount of dye is injected into each of the two needles to stain both the inferior and the anterior surface of the diseased disc

The injection of multiple cervical discs may be carried out if the clinical findings and preliminary roentgenograms do not give a clue as to the level of the suspected lesion If more than one disc is to be investigated the entire procedure described above for the study of a single disc should be completed before investigating the next level and a repetition of the procedure carried out for each successive level

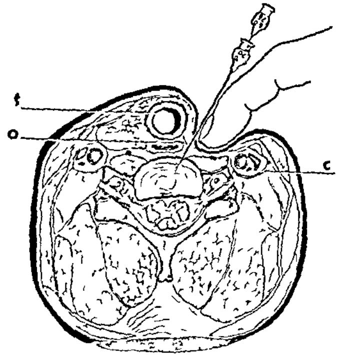


Fig 2 Diagram of cross section of neck to show direction and position of needles t — trachea o — esophagus c — carotid



Fig 3 Normal cervical discogram Contrast medium injected into nucleus pulposus of 3rd, 4th and 5th discs

In some clinics it has been the practice to insert a needle into two or more adjacent cervical discs for simultaneous injections of multiple levels Such a film (from a cadaver) showing needles in two interspaces was included in the illustrations of my original paper on cervical discography (CLOWARD 1958) I strongly advise against cervical discography done in this manner for two reasons First it is extremely important to displace the trachea and the esophagus laterally before insertion of the needle because of the danger of passing the needle through the esophagus before entering the disc which may lead to contamination and serious infection When the needle has been placed in a disc it is impossible properly to displace the larynx and esophagus for insertion of another needle into an adjacent disc without dislodging the first needle Secondly the most valuable information obtained from the injection of the disc is the pain experienced by the patient The full clinical value of this subjective information is lost if more than one disc is injected simultaneously and if the procedure is carried out under general anesthesia so that the patient is unable to report the site of the pain

One should also warn against the use of the single needle technique for disc puncture The initial multiple stabs along the anterior surface of the vertebral bodies with the guide needle which are frequently necessary to locate the anterior surface of the disc may produce a hook or a barb on the point of the needle No serious harm will be done to the disc if this needle is inserted only into the outer fibers of the annulus fibrosus a distance of one or two millimeters However if this hooked needle is passed on through the disc and into the nucleus pulposus an antero lateral tear or laceration of the disc may result On the other hand if a fine sharp needle is passed into the disc through the guide needle there is little risk of injuring a normal disc



Fig 4 Discograms of unilateral (right view) and bilateral (left view) (postero-lateral) disc ruptures

Discussion

Indications and contra indications Cervical discography is indicated in the diagnosis of all clinical pain syndromes and neurologic disorders in which a lesion of the cervical spine or a cervical intervertebral disc is suspected to be the cause such as

Acute trauma to the cervical spine (the whip-lash injury), in which a cervical disc injury with or without intraspinal protrusion is suspected clinically

Fractures and fracture dislocations of the cervical spine with neurologic evidence of cervical cord or nerve root involvement which could be due to an intraspinal disc protrusion

Cervical spondylosis (chronic disc degeneration) with osteophyte formation on the posterior or postero-lateral margins of the vertebral bodies and associated neurologic deficit or the neck shoulder and arm pain syndrome or both

Impairment of spinal cord or nerve root function and myelographic evidence of obstruction of the spinal canal suggesting intraspinal neoplasm a cervical discogram at the level of the obstruction may demonstrate the lesion to be a massive intraspinal disc protrusion thus giving a preoperative pathologic diagnosis

The only contra indication to performing the discography which I have encountered is the presence of local injury or infection in the tissues of the neck Obviously the passage of the needle through contaminated or infected tissue and into the intervertebral disc should never be done If the patient has an

upper respiratory infection with cervical adenopathy, the procedure should perhaps be postponed until adequate antibiotic therapy has been administered.

Advantages of discography over cervical myelography As is the case with the lumbar discogram (DE HAENE 1955, LAEO 1957, LINDSTROM 1960) the cervical discogram has many advantages over cervical myelography The discogram is a safer and much simpler procedure It may be performed on a roentgen table, a hospital cart, or even in the patient s bed using portable roentgen equipment The patient remains quietly in a supine position and there is no need for turning or twisting, or for manipulation of the cervical spine, and there is no need for placing the patient in head down position as is required for the myelogram The contrast medium that has been injected into the cervical disc is readily absorbed and does not require removal The large quantity of contrast medium which has to be injected into the spinal canal for cervical myelography if opaque oil is used, may require considerable time and effort for its removal. Residual oil globules remaining in the intracranial or sacral subarachnoid space may be the source of symptomatic or legal complications

The roentgen investigation of the presence of pathologic cervical disc by myelography gives only information concerning the presence of disc fragments which have invaded the spinal canal The discography, in addition to outlining these lesions, also demonstrates the non herniated disc ruptures and gives positive information as to whether the disc lesion is responsible for the neck shoulder and arm pain

Disadvantages and complications of cervical discography SMITH (1959) has stated that there are three disadvantages to cervical discography, namely (1) no information is obtained concerning the spinal canal or cerebro-spinal fluid, (2) there is danger of introducing infection into the disc, and (3) pathologic changes can be demonstrated in a high percentage of discs injected, which makes interpretation difficult These disadvantages are minor compared to the advantages and the valuable information obtained with the procedure

1 If a cervical cord lesion is suspected clinically from the history and the neurologic findings, lumbar puncture with manometric studies and spinal fluid examination are routinely carried out prior to diagnostic roentgenographic procedures A suspected spinal cord tumor should be investigated by myelography But as stated above, if a disc lesion is suspected, discography is also carried out and additional diagnostic information on the nature of the lesion can be obtained

2 The most serious complication to cervical discography is the possibility of contaminating the intervertebral disc by the puncture, on account of the close proximity to the esophagus If the examination is not properly executed, the needle may pass through the esophagus and into the disc and serious complications may result Infection of a lumbar disc following disc puncture has

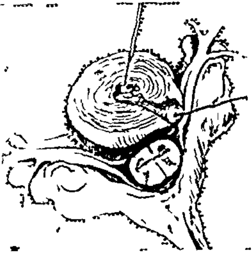


Fig 5 Diagram showing nerve root compression by herniated disc fragments (indicated by the black line the direction of the discogram needle is shown above)

been reported by EPPS (1942) and BROMLEY et coll (1949) These cases of septic necrosis of the disc followed lumbar puncture for meningitis Discitis as a complication of discography has been reported by DE SEZE and LEVERNIEUX (1952) in 13 cases out of 59 cases subjected to discography GARDNER et coll (1952) reported one case of discitis out of 89 and NORLANDER et coll (1958) one out of 500 cases This complication was also reported by DE HAENE and DEL BEKE (1955), and LINDSTROM (1960) who had 5 cases

In my experience with lumbar discography over twelve years only one case, in a series of nearly 1 500 lumbar discographies, was encountered in which definite evidence of disc contamination (discitis) occurred and was verified at operation In a series of over 300 cervical disc lesions operated upon by the anterior approach 3 cases have been encountered with severe disc infections attributed to disc contamination by improperly performed cervical discographies (done elsewhere) This would indicate in my practice at least, that infection in the cervical disc as a complication of discography is ten times as frequent as in the lumbar discs

3 The third disadvantage of discography concerns the pathologic changes and interpretation of the discographic findings These will be discussed under the pain mechanism and roentgenographic interpretation

Discographic pain Since the introduction of discography it has been recognized that pain is produced by disc injection In 1948 LINDBLOM writes If his usual sciatic pain becomes worse by injection it means that the punctured disc is the ruptured one responsible for the root or nerve compression In patients who clinically show symptoms of lumbago and sciatica, these pains were reproduced at the moment of injection for discography There are

different interpretations as to the origin and cause of discographic pain Some writers maintain that a pathologic disc, to be symptomatic, must bulge or herniate to the periphery of the disc, or rupture through it, producing so called 'tissue sequestra (WALK 1953) These herniated masses can be demonstrated by discography The pain results from transmission of pressure of the injected fluid to the overlying nerve root Others (GARDNER et coll 195?) (WALK 1953, 1956) believe that a discographically verified ruptured disc which reveals no bulging mass at operation, is due to the contrast medium flowing back along the needle tract or the canal of puncture The concept of false positive discogram was thus introduced Others are of the opinion (PEREY 1951, CLOWARD 1953, WALK 1953, NORLANDER, SALEN and UNANDER SCHARIN 1955, and others) that a complete internal rupture of the disc, that is, one in which the rent reaches the surface of the disc, can be demonstrated by discography to produce clinically experienced pain although no herniated disc is found at operation These simple internal disc ruptures may be the cause of invalidating pain The cause of this pain clinically, is thought to be due to stimulation or irritation of the sensory nerves located in the peripheral fibers of the disc by movements of the spine with weight bearing This discographic pain is due to irritation of peripheral nerve fibers in the disc by mechanical stimulation of the injected fluid The increase in intradiscal pressure is transmitted to the periphery of the disc through the rupture or rent

For a long time there was question as to whether the intervertebral disc is sufficiently supplied with sensory nerve element to be called a pain producing tissue (STEINDLER 1959) Because of the inaccessibility of lumbar intervertebral discs to direct stimulation, conclusions as to disc sensitivity could only be drawn from indirect stimulation with discography With the advent of anterior cervical disc surgery however, and the accessibility of the cervical disc to direct stimulation under local anesthesia, it has been positively determined that the intervertebral discs are richly supplied with sensory nerves (sinu vertebral nerve) and can be definitely included in the pain producing tissues (CLOWARD 1959)

Three distinct types of pain can occur from the injection of a fluid medium into a pathologic cervical disc In addition to the normal intervertebral disc with an intact annulus fibrosus which causes little or no pain, the patient may experience a discogenic pain, a neurogenic pain, or a myologenic pain or there may be various combinations of these three distinct types

The discogenic pain has its origin in the sensory nerve supply to the intervertebral disc the sinu vertebral nerve Stimulation of this nerve, which is located in the deep peripheral fibers of the annulus fibrosus and the anterior and posterior longitudinal ligament produces a pain of myalgic or sclerotogenous nature referred to the muscles along the vertebral border of the scapula posterior deltoid and posterior outer surface of the upper arm Occasionally this referred pain will be transmitted to the anterior chest wall In unilateral



Fig 6 Cadaver cervical spine Methylene blue dye injected into the disc escapes towards opposite side through old defect (arrow) in the anterior fibers of annulus fibrosus The rupture was demonstrated by contrast medium injection into the disc (see insert)

disc ruptures the pain occurs on the ipsilateral side of the body when the disc is injected for discography Extensive bilateral rupture or disc degeneration may produce bilateral pain This pain of disc origin, can be produced by direct stimulation of the anterior surface of the cervical discs exposed for operation and can be relieved by injection of local anesthetic into the interior of the disc through the needle

The neurogenic pain A bulge or protrusion of the disc or sequestrations of disc fragments into the spinal canal may cause the increased intradiscal pressure from the injected fluid to be transmitted to a nerve root or to the spinal cord The neurogenic pain is almost always unilateral and may be described as a shock of pain extending along the dermatome and having an electricity like quality or as a burning sensation

The myelogenic pain Clinical evidence of involvement of the spinal cord can be identified as being due to a protruded disc mass by producing a myelogenic pain when the disc is injected The patient will experience the phenomenon of spinal cord compression described by Lhermitte as an electric shock which radiates throughout the entire body involving all four extremities

A fourth category can be described as a painless disc a disc which is obviously pathologic in the discogram but which causes no pain on injection This finding occurs with two lesions A large tear or rupture in the disc which is almost always present in anterior dislocations of the cervical spine will permit the injected fluid rapidly to escape from the disc the intradiscal pressure, therefore is not increased and the patient may experience no pain or if pain

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Fig 8 Discogram of degenerated disc The interspace is entirely (to the periphery) filled with contrast medium

to the midline limits of the nucleus pulposus extending to the outer margin of the disc in the vicinity of the joint of Lushka if the peripheral annulus is unruptured If these fibers are torn or a free fragment is herniating through the tear the contrast medium escapes beyond the disc and may outline the herniated fragment or extend into the paravertebral space or along the nerve root These lesions may be unilateral (Fig 4a) or bilateral (Fig 4b)

The contrast material may extend anterior to the nucleus pulposus or even run out of the interspace and appear in quantity along the anterior surface of the vertebral body This may represent a traumatic laceration in the anterior disc fibers not infrequently encountered in acute disc injuries of the whip lash type or it may be a feedback of the contrast medium along the needle track These traumatic anterior disc defects have been demonstrated by injection into degenerated discs in cadavers which suggests that they may not heal but remain open (Fig 6)

Anterior dislocation of the cervical spine is almost always associated with an acute laceration of the disc This is recognized by a passage of contrast medium outside the intervertebral space In the posterior laceration the contrast medium flows into the anterior epidural space above and below the disc lesion (Fig 7a) This is exceedingly valuable in demonstrating the presence of herniated torn disc fragments within the spinal canal causing spinal cord compression The routine use of discography in patients with fracture dislocations has demonstrated this lesion to exist in a high percentage of cases, occurring much more frequently than was ever suspected prior to discography A minimum of 1 ml of contrast medium should be injected in these cases to delineate intraspinal lesions Anterior disc lacerations are recognized by contrast medium in quantity on the anterior surface of the spine (Fig 6 insert)



a b

Fig 7 a) Discogram of lacerated disc (dislocation reduced by traction) The contrast medium has escaped into the epidural space b) Intraspinal herniation of massive disc sequestrum in quadriplegic patient with myelographic block

does occur from passage of the fluid through the disc laceration it is of the discogenic type The chronic degenerated disc of long standing with a very narrow intervertebral space and extensive marginal osteophytes is occasionally painless when injected, this is thought to be due to reactionary fibrosis of the peripheral fibers of the disc with destruction of its sensory nerve system

Interpretation of discographic appearances

A normal, intact nucleus pulposus in the lower cervical spine will accept only 0 2 to 0 3 ml of fluid The contrast medium will stay only in the nucleus pulposus, which is seen as a spherical or oval shape almost in the center of the intervertebral space (Fig 3) Occasionally a small thin tongue or spike of the contrast medium extends lateral or posterior to the nucleus, but does not reach the periphery of the disc These are normal extensions of the nucleus and do not represent a rupture of the annular fibers

A fresh or recent disc rupture may be suspected when the preliminary roentgenograms show normal, wide intervertebral spaces without osteophyte formation Single or multiple ruptures, rents or lacerations in a disc will permit the injected contrast medium to extend to or beyond the peripheral limits of the intervertebral space This represents a pathologic disc The posterior, or posterolateral rupture, as in the lumbar discs is the most frequently encountered lesion In the antero posterior projection the contrast medium is seen lateral



a b

Fig 9 a) Degenerated disc with large posterior osteophytes C4—5 b) Discogram outlines posterior ligament annulus detached from osteophytes gives false impression of massive lesion (arrows) Anterior defects are present as well

This must be differentiated from 'normal anterior defects of the degenerated disc and from feed back' spill over due to an improperly executed injection (WITT 1954)

In the degenerated disc with or without marginal osteophytes a complete disorganization of the interior of the disc is evident by the contrast medium completely filling the intervertebral space It extends to the periphery in the antero-posterior and lateral projections (Fig 8) The degenerated disc with large posterior osteophytes has a characteristic appearance (Fig 9a) The contrast medium escapes through a narrow channel between the posterior margins of the vertebral bodies and then spreads out beneath the posterior longitudinal ligament over the osteophytes assuming the contour of a collar button or mushroom Some of these may appear extraordinarily large in that the head of the mushroom occupies nearly half of the transverse diameter of the spinal canal (Fig 9b) Clinical evidence of spinal cord involvement might be expected from the size of these lesions The majority of them, however cause no neurologic signs and the pain at the injection is of the discogenic type The reason is that the lesion is actually not as large as the discogram would indicate Apparently the posterior longitudinal ligament and the peripheral annulus in the degenerated collapsed disc are no longer taut as in a normal disc but are relaxed and redundant Also instead of being adherent to the vertebral margin as one might suspect, these ligaments are loose and become detached from the osteophyte but remain attached to its base This forms a pocket over the osteophyte which when filled and distended by contrast medium gives the false impression of an enormous intraspinal lesion (Fig 9b) These pockets may also be found in acute disc lesions without osteophyte

formation Intraspinal protrusions of sequestrated disc mass may stretch and detach the ligament without rupturing through it

Finally there is the intraspinal protrusion or displacement of a large disc mass causing spinal cord compression and quadriplegia or quadriparesis These lesions which produce obstruction of the spinal canal are suspected clinically of being neoplasms The true pathologic nature of the lesion can be demonstrated by discography (Fig 7b) With a pre-operative diagnosis of a pathologic disc mass lying anterior to the cervical cord, an operation for removal of the lesion by an anterior approach may be planned

SUMMARY

Cervical discography is a valuable addition to the roentgenographic investigation of lesions of the cervical intervertebral discs and the diagnostic information obtained is superior to what cervical myelography may reveal The examination can be performed outside the roentgen department if necessary with the aid of a portable equipment If properly performed there are no complications but infection of the disc which is the most serious complication may occur if the needle perforates the esophagus The usefulness of discography in the clinical investigation of cervical syndromes is stressed

ZUSAMMENFASSUNG

Cervicale Diskographie ist eine wertvolle Ergänzung zur Röntgenuntersuchung von Schaden der cervicalen Zwischenwirbelscheiben An diagnostischer Bedeutung ist sie der cervicalen Myelographie überlegen Die Untersuchung kann wenn nötig ausserhalb einer Röntgenabteilung mit Hilfe transportabler Geräte vorgenommen werden Bei gewissenhafter Durchführung sind Komplikationen praktisch ausgeschlossen Es kann jedoch zur Infektion des Diskus kommen vor allem dann wenn die Nadel den Ösophagus perforiert was eine sehr ernste Komplikation bedeutet Die Anwendbarkeit der Diskographie in der klinischen Diagnose des cervikalen Syndroms wird hervorgehoben

RÉSUMÉ

La discographie cervicale est un complément utile des examens radiologiques de lésions des disques intervertébraux cervicaux les renseignements diagnostiques qu elle fournit sont supérieurs a ceux que peut donner la myélographie cervicale Cet examen peut etre pratiqué hors du service de radiologie si nécessaire au moyen d un appareil portatif Quand il est exécuté convenablement il n entraine pas de complication mais il peut se produire une infection du disque qui est la complication la plus grave quand l aiguille perfore l oesophage L auteur souligne l utilité de la discographie pour l etude des syndromes cervicaux

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SERVICE DE NEURO-CHIRURGIE (CHEF G MAZARS) DE L HOPITAL SAINTE ANNE
PARIS FRANCE

PHLEBOGRAPHIE RACHIDIENNE PAR VOIE TRANS EPINEUSE

par

R DJINDJIAN A PANSINI et P DORLAND

L anatomie veineuse du rachis a ete decrite depuis le début du XIX siecle BRESCHET (Fig 1 et 2) entre autres a montre les plexus intra et extra rachidiens leurs anastomoses et leurs communications avec les veines du pelvis et les sinus craniens L opacification du systeme veineux en general par injection d un produit de contraste dans la moelle osseuse etait un fait bien connu aussi l a t on appliquee au rachis en ponctionnant soit l apophyse epineuse, soit le corps vertebral lui meme

La voie epineuse nous a paru la plus favorable (1) par sa facilite d execution saillie de l apophyse sous les doigts abord tres superficiel sous cutane permettant une novocainisation progressive (2) par son innocuité aiguille libre non comprimee par les masses musculaires ne frolant pas des vaisseaux arteriels ou veineux , (3) par la qualite de ses images injection nette des plexus extra rachidiens posterieurs pas toujours visibles par l injection corporéale, surtout injection bilaterale des plexus parce que la ponction est mediane, ce qui n est pas obtenu lors des injections lateralisées

Technique

Le materiel est simple et comprend une aiguille un marteau et une seringue avec un raccord L aiguille utilisee est le trocart pour ponction sternale

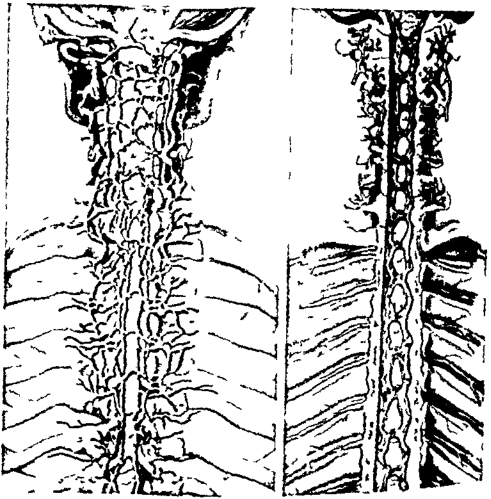


Fig 1 Planches anatomiques de Breschet

dont il faut aiguiser le biseau après chaque ponction Nous l'avons préférée à l'aiguille à vis qui crée un puits d'où parfois reflue l'iode

Le malade est placé en decubitus ventral, en faisant saillir au maximum les apophyses épineuses intéressées au moyen de coussins provisoires, on enfonce alors le trocart, sur la partie saillante de l'épineuse de quelques millimètres et celui ci sera jugé bien en place s'il se trouve immobilisé et solidaire de l'épineuse lorsqu'on fait remuer le malade

La ponction de l'épineuse est parfois difficile lorsque la corticale de l'épineuse est trop épaisse et de ce fait très dure c'est pourquoi nous utilisons dans ces cas un marteau qui nous permet d'enfoncer progressivement le trocart dans l'épineuse sans soumettre ainsi le malade à une pression désagréable, nous n'avons jamais obtenu de torsion, ou de rupture du trocart

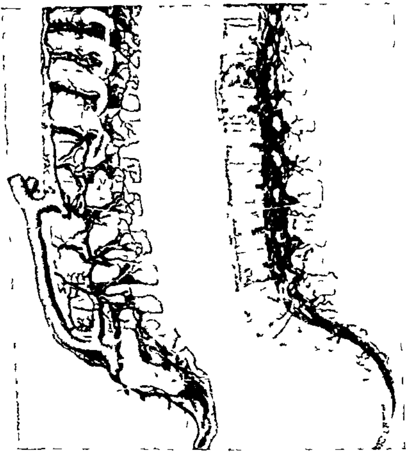


Fig 2 Planches anatomiques de BRESCHET

Lorsque au contraire, l apophyse est trop friable ou difficilement perceptible, nous preferons l abord chirurgical, exposant la partie teminale de l apophyse que l on ponctionne avec le trocart ou l injection corporeale L aiguille en place on enleve le mandrin et il n est pas exceptionnel de voir s ecouler quelques gouttes de sang

La ponction faite un raccord en plastique est ajusté à l aiguille d une part et à une seringue metallique de 20 ml d autre part Le produit de contraste est un triode concentre a 50 % dont nous injectons environ 15 ml Les cliches sont pris simultanement de face et de profil toutes les secondes pendant 10 secondes sur un seriographe La pression a imprimer a la seringue doit etre importante parfois elle est considerable Si l on n observe pratiquement pas de résistance, c est que l aiguille est hors de l epineuse ou a perforee celle ci latéralement, le malade ressent dans ce cas une brulure transitoire et sur le cliché l on observe

une flaque de produit de contraste (Fig 3) Nous n avons jamais observé d incidents ou d accidents par cette methode ni rupture de l aiguille, ni infections, ni embolies

Bref rappel radiologique

1 *Phlebographie rachidienne de profil*

Nous prendrons comme exemple un segment vertebral (Fig 4) qui repond a l aspect le plus schematique que celui de la région dorsolombaire (Fig 5)



Fig 3 Flaque de produit de contraste (injection hors de l epineuse)

Le plexus extra rachidien posterieur forme a l extremite anterieure du trocart un lacis veineux sur l apophyse epineuse de ce lacis épineux partent deux veines transversales se dirigeant vers le trou de conjugaison qu elles atteignent , ces veines peri epineuses de calibre variable, plus ou moins tortueuses parfois remplacees par plusieurs veinules, communiquent par des arcades a concavite anterieure avec leurs homologues sus et sous jacentes formant des arcs inter epineux La reunion des arcs inter epineux est parfois doublee de veinules qui relient les plexus rachidiens posterieurs d etages differents ces veines sous cutanees montent le long des apophyses epineuses sacrees lombaires et dorsales et repondent parfois a la veine mediane du dos ou azygos dorsi de Godman Les plexus extra rachidiens posterieurs convergent vers le trou de conjugaison ou l on retrouve sur les clichés l opacification des plexus intra rachidiens realisant un lacis plus ou moins irregulier mais facilement reconnaissable par sa situation plaquee contre le rebord vertebral posterieur Ces plexus forment une ligne discontinue verticale s anastomosant avec les segment sus et sous jacents et constituant au niveau des trous de conjugaison un renflement repondant a un veritable carrefour veineux (plexus du trou de conjugaison)

Le plexus extra rachidien anterieur De ce carrefour veineux se dirige d arriere en avant une grosse veine latero vertebrale cheminant transversalement au milieu de la face laterale du corps vertebral elle n est pas horizontale mais decrit une courbe moderée a concavité inferieure il existe une veine latero-vertebrale de chaque cote du corps vertebral s anastomosant pour realiser le

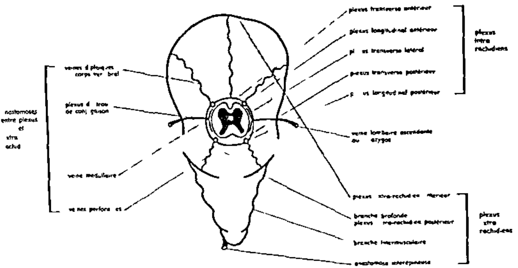


Fig 4 Coupe d un segment vertébral

plexus extra rachidien anterieur Ces deux veines sont parfois visibles sur des cliches qui ne sont pas rigoreusement de profil Cette grosse veine se jette a angle droit dans l azygos a partir de D12 chaque veine a chaque étage formant un aspect scalariforme caracteristique dans la region dorsale l azygos a l as pect d un vaisseau vertical de calibre croissant situe en avant des corps verte-braux on la voit se jeter par une crosse dans la veine cave superieure

2 *Phlébographie rachidienne de face*

L aspect radiologique de face (Fig 6) est beaucoup moins net que celui de profil car il existe une superposition des plexus intra rachidiens et des plexus extra rachidiens (Fig 7)

Les plexus intra rachidiens forment deux bandes anastomotiques longitudinales sinueuses logees a la peripherie du canal medullaire les deux bandes sont reliees entre elles par un pont veineux au niveau du corps vertebral represen tant les plexus transverses anterieur et posterieur Entre les ponts veineux les veines longitudinales s ecartent formant un aspect en accent circonflexe du sommet duquel s echappe le plexus du trou de conjugaison

Les plexus extra rachidiens anterieur et posterieur apparaissent sur les cliches avec une grande complexite et on peut schematiser la description par deux bandes veineuses longitudinales laterales deux bandes longitudinales para médianes enfin une bande veineuse transversale

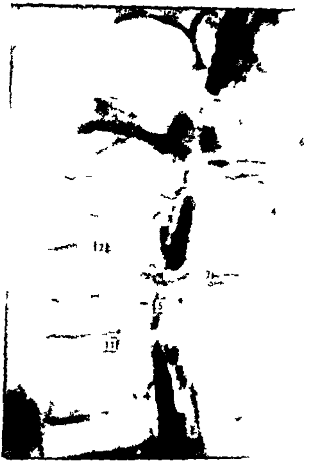


Fig 3 Phlebographie de profil 1 — veine lombaire ascendante 2 — plexus extra rachidien anterieur 3 — veine periepineuse 4 — lacis epineux 5 — plexus intra rachidien 6 — anastomoses posterieures (veine azygos dorsi

Les bandes anastomotiques longitudinales laterales cheminent de chaque co du corps vertebral formant une bande sinueuse epousant le rebord vertebral elle est constituee de branches anastomotiques des plexus du trou de conjugaison des veines peri medullaires extra rachidiennes des plexus extra rachidiens

Les bandes anastomotiques longitudinales para medianes forment deux bandes veineuses situees de part et d autre de la ligne des epineuses ces bandes ne sont pas rectilignes mais realisent une disposition assez reguliere donnant une image en point d interrogation Entre ces deux bandes medianes on trouve l extremite du trocart avec le lacis epineux, et parfois des veinules anastomotiques le long des epineuses realisant la veine azygos dorsi.

Les bandes anastomotiques transverses relient d une part les systemes anastomotiques longitudinaux medians passant au-dessus et au-dessous d

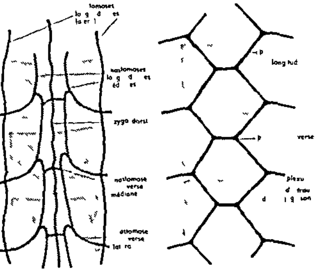


Fig 6 Phlebographie de face

l apophyse epineuse d autre part les bandes longitudinales laterales sous forme d une veine de calibre plus ou moins important cheminant non pas au niveau du disque mais a la partie basse du corps vertebral juste sous le pedicule Ainsi ces anastomoses longitudinales laterales et para medianes et transversales forment un veritable cercle veineux autour du pedicule osseux

Application aux cas pathologiques

Les images radiologiques des veines epidurales sont obtenues tres facile ment quel que soit le segment vertebral si on prend soin de placer l aiguille correctement dans l apophyse epineuse

Hernies discales (Fig 8b) Nous avons etudie les modifications possibles du phlebogramme au cours des hernies discales Il est intéressant pour ces lesions d etudier l anneau peri articulaire et le plexus du trou de conjugaison qui peuvent etre le siege de modifications Les anomalies consistent en une gene du passage des plexus veineux avec parfois deplacement des vaisseaux et surtout augmentation de calibre des veines temoignant d une stase veineuse

Angiomes de la moelle (Fig 8a) La phlébographie n a pas apporté d elements positifs en faveur des angiomes ou des varices intra durales dessinees par le lipiodol Peut etre que des malformations vasculaires extra duremeriennes associees a des angiomes osseux seraient susceptibles de s injecter, mais nous n en avons pas observe jusqu a maintenant



Fig. 5. Phlébographie de profil. 1 — veine lombaire ascendante. 2 — plexus extra rachidien antérieur. 3 — veine périépineuse. 4 — lacis épineux. 5 — plexus intra rachidien. 6 — anastomoses postérieures (veine azygos dorsi).

Les bandes anastomotiques longitudinales latérales cheminent de chaque côté du corps vertébral formant une bande sinueuse épousant le rebord vertébral ; elle est constituée de branches anastomotiques des plexus du trou de conjugaison, des veines péri médullaires extra rachidiennes, des plexus extra rachidiens.

Les bandes anastomotiques longitudinales para médianes forment deux bandes veineuses situées de part et d'autre de la ligne des épineuses ; ces bandes ne sont pas rectilignes, mais réalisent une disposition assez régulière donnant une image en point d'interrogation. Entre ces deux bandes médianes on trouve l'extrémité du trocart avec le lacis épineux et parfois des veinules anastomotiques le long des épineuses réalisant la veine azygos dorsi.

Les bandes anastomotiques transverses relient d'une part les systèmes anastomotiques longitudinaux médians passant au dessus et au-dessous de

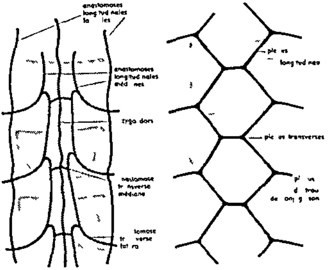


Fig 6 Phlébographie de face

l'apophyse épineuse d'autre part les bandes longitudinales latérales sous forme d'une veine de calibre plus ou moins important cheminant non pas au niveau du disque mais à la partie basse du corps vertébral juste sous le pédicule Ainsi ces anastomoses longitudinales latérales et para médianes et transversales forment un véritable cercle veineux autour du pédicule osseux

Application aux cas pathologiques

Les images radiologiques des veines épidurales sont obtenues très facilement quel que soit le segment vertébral, si on prend soin de placer l'aiguille correctement dans l'apophyse épineuse

Hernies discales (Fig 8b) Nous avons étudié les modifications possibles du phlébogramme au cours des hernies discales Il est intéressant pour ces lésions d'étudier l'anneau péri articulaire et le plexus du trou de conjugaison qui peuvent être le siège de modifications Les anomalies consistent en une gêne du passage des plexus veineux avec parfois déplacement des vaisseaux et surtout augmentation de calibre des veines témoignant d'une stase veineuse

Angiomes de la moelle (Fig 8a) La phlébographie n'a pas apporté d'éléments positifs en faveur des angiomes ou des varices intra durales dessinées par le lipiodol Peut être que des malformations vasculaires extra duremériennes associées à des angiomes osseux seraient susceptibles de s'injecter mais nous n'en avons pas observé jusqu'à maintenant

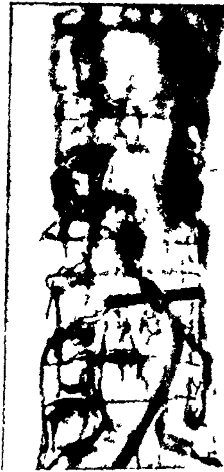


Fig 7 Phlebographie de face

Parmi les *tumeurs medullaires et rachidiennes*, les anomalies observees ont ete le fait de tumeurs richement vascularisees ou de tumeurs osseuses rachidiennes. Les méningiomes fournissent une hypervascularisation avec dilatation des veines, et parfois une distension des plexus (Fig 9) Un cas d angio-réticulome vertébro medullaire a fourni outre une image hypervascularisée un deplacement des veines avec image bordante (Fig 10a) Enfin les metastases rachidiennes semblent les plus evocatrices par la densite veineuse et surtout la dilatation au niveau et a distance des plexus intra et extra rachidiens (Fig 10b)

Traumatisme La phlebographie nous apparait d un grand interet dans les cas ou les dislocations osseuses s accompagnent de lesions veineuses (compression distension, stase) (Fig 11)



a b

Fg 8 a) Angiome de la moelle (Absence d injection de l angiome D1?—L2 vérifie ch rurgicalement.) b) Herme discale L5—S1 gauche (plexus non injecte du coté gauche dilatation veineuse sous le disque)

Conclusions

La phlebographie trans osseuse s est révelée jusqu ısı comme une methode radiologique utile dans les processus interessant le corps vertebral et les lame l espace epidural ou ces deux localisations a la fois Il est certain que les metastases osseuses ou epidurales sont les cas les plus favorables pour fournir des images anormales

Nous ne sommes pas encore au stade de pouvoir affirmer comme certains auteurs l existence d une compression médullaire ou d un hernie sur la simple phlebographie nous ne saurions nous passer des myélographies par lipiodol ou substances resorbables au contraire ces méthodes sont d un apport capital pour pouvoir comparer les deux techniques



Fig 10 a) Angio-réticulome lombaire vérifié chirurgicalement déplacement des vaisseaux et injection d'une partie kystique b) Métastase osseuse (dilatation veineuse à distance)

RÉSUMÉ

Les auteurs décrivent la technique de la phlébographie rachidienne par voie trans-épineuse et les aspects normaux des plexus intra et extra rachidiens. Ils donnent des exemples de l'application de cette technique aux hernies discales, aux angiomes, aux tumeurs de la moelle et du rachis, aux traumatismes. D'après leur expérience actuelle, cette technique ne suffit pas pour affirmer l'existence d'une compression médullaire ou d'une hernie discale: la myélographie reste indispensable.

SUMMARY

The technique of spinal phlebography via the spinous processes and the normal appearances of the intra and extraspinal plexuses are described. Examples are given of the application of the techniques in the examination of disk herniation, angiomas and tumours of the cord and spine as well as injury. Experience appears to have shown that the method is not always adequate for the confirmation of medullary compression or disk herniation: myelography is regarded indispensable.

ZUSAMMENFASSUNG

Die Technik der spinalen Phlebographie durch die Dornfortsätze und die Röntgenbilder der intra- und extraspinalen Venengeflechte werden beschrieben. Beispiele zeigen die Anwendung der Methode bei Diskprolaps, Angiomen, Geschwülsten des Rückenmarks und der Wirbelsäule und Wirbelverletzungen. Die Erfahrung lehrt, dass die Methode nicht immer genügt, um Druck auf das Rückenmark oder Diskprolaps zu erkennen. Die Myelographie bleibt unentbehrlich.

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MYELOGRAPHIC ASSESSMENT OF OCCULT FORMS OF SPINAL DYSRAPHISM

by

GORDON I GRYSPEERDT

The term spinal dysraphism was revived by LICHTENSTEIN to cover a group of developmental anomalies due to failure of complete development of the embryo in the median dorsal plane

JAMES and LASSMAN (1962) working at the Newcastle General Hospital have investigated clinically a series of unexplained progressive foot deformities in children, in some of which it became obvious during the course of the research that the deformities were due to lesions of the spinal cord and cauda equina. These cases conformed to a pattern which ultimately permitted the formulation of a syndrome (JAMES and LASSMAN 1960) The material from this clinical study by JAMES and LASSMAN has been referred to the author for radiologic investigation and fifty one of these selected patients have been submitted to radiologic study of the vertebral column including positive (oily) contrast myelography

The majority of the cases referred for radiologic investigation exhibited the orthopaedic syndrome of spinal dysraphism a minority presented with other neurologic signs and symptoms, or with external manifestations of a congenital anomaly of the spine without neurologic deficit Consequent upon the clinical assessment and the myelographic findings, forty of the selected group of patients have undergone laminectomy Operation has demonstrated the presence of



Fig 1 Double tilting table with linked undercouch and lateral tube heads Subject secured by special harness

lesions involving the spinal cord or cauda equina which could be shown to act by traction, by pressure or by a combination of both traction and pressure and it was found that these lesions were amenable to surgery While the intention of the operation is to prevent further progression of the neurologic deficit, subsequent follow up of between nine and forty months has shown positive improvement in some respect in two-thirds of the patients Only in two cases in the operated group was no lesion found in the theca or spinal cord and in these two cases the appearances at myelography were normal

Midline septa associated with diastematomyelia, intrathecal lipomata dermoid cysts or involvement of the spinal cord and cauda equina by bands or adhesions may be demonstrable by myelography Survey radiography of the vertebral column in this selected series has demonstrated a definite defect in the development of the neural arches of one or more vertebrae varying from a minor defect in the laminae posteriorly to more major and bizarre bone anomalies associated with failure of normal bony development in the median dorsal plane One of the criteria in selection of patients for myelography in this series was the presence of a definite defect in the development of the laminae in one or more regions of the vertebral column more commonly presenting in the lower half of the spine Review of the series of operated cases has shown that the degree of laminal defect seen in the survey films was always greater than the simple failure of fusion of the laminae in the lumbo sacral region, so frequently observed in radiologic practice in which the laminae are developed but the spinous process remains bifid or deficient

All radiologists are familiar with the variable appearances of the more gross anomalies of arrest or mal development of the neural arches often with widening of the interpedicular distances inversion of the laminae fusion of



Fig 2a



Fig 2b



Fig 3a



Fig 3b

Fig 2 Female aged 12 years a) Prone position normal terminal theca b) Supine terminal theca tilted to angle where contrast medium is commencing to flow upwards Filum terminale is seen as a linear faint outline in midline within the contrast medium

Fig 3 Myelograms in male aged 8 years a) Supine filum terminale widens to form apex of conus medullaris at level of upper margin of L2 vertebra b) Prone the vessel on anterior aspect of spinal cord can be traced to upper margin of body of L2 vertebra but no lower thus confirming the level of conus medullaris

adjacent laminae and sometimes with evidence of a bony midline septum or spur the whole picture not infrequently complicated by more extensive developmental anomalies of the vertebral bodies and pedicles Such gross examples of spinal dysraphism are well covered by descriptive studies in the literature and several papers have dealt in detail with diastematomyelia associated with a demonstrable septum within the spinal canal (NEUHAUSER WITTENBORG and DEHLINGER COWIE (1951) (1952) (1956), SANDS and CLARK SEAMAN and SCHWARTZ, BLIGH) Detailed myelographic interpretation of the

whole group of occult forms of spinal dysraphism has however received scant attention due to the prevailing opinion in the past that the majority of the congenital anomalies involving the spinal cord were inoperable or unlikely to benefit from surgery

Technique Positive contrast myelography rather than gas myelography has been employed as small structures such as the anterior spinal artery and the filum terminale in the author s opinion are more easily identifiable by this method The contrast medium used is ethyl iodophenylundecylate (Myodil or Pantopaque) and the approximate optimum quantity for this type of case is 2 ml in a three year-old child to 3 5 ml in a 15-year-old child too small a quantity hinders interpretation, too large a quantity obscures detail of intrathecal structures

The contrast medium is introduced via cisternal puncture under general anaesthesia In the earlier cases in this series introduction by lumbar puncture under local anaesthesia was employed but experience has shown that the conus medullaris is likely to be low placed if the spinal cord is involved in the developmental anomaly and there would therefore be a risk of trauma to the spinal cord from lumbar route injection Careful search at myelography has failed to show an Arnold Chiari deformity in a consecutive series of thirty two cases with occult forms of spinal dysraphism and cisternal puncture is therefore regarded as a safe procedure in these cases The technique of general anaesthesia employed during the myelographic investigation has been described by WHITBY

A double tilting table is employed with linked undercouch and lateral tube heads capable of fluoroscopy and radiography in two planes at right angles with any degree of tilt of the table in either direction (Fig 1) The child is initially placed prone in a special harness and the theca is examined from the upper cervical region to its lower limit by fluoroscopy and when indicated by radiography

Radiography in two planes is essential for the proper interpretation of the appearances Further examination in the supine position is necessary for the study of the filum terminale the detection of a low placed conus medullaris the identification of bands and adhesions between the spinal cord and the dura mater and the study of the posterior wall of the theca

Radiation of the subject must be kept to a minimum by closing the diaphragms to cover only the column of contrast medium during fluoroscopy and radiography

Myelographic assessment

The level of the conus medullaris The appearances of the normal theca using an oily positive contrast medium in the prone position are well known In the terminal theca the filum terminale is rarely identifiable in the prone myelogram but if the subject is placed supine the filum terminale which lies posteriorly in the spinal canal at this level, is almost invariably shown in the midline (Fig 2) If, with the subject supine the table is slowly tilted with the head downwards the contrast medium may flow upwards from the terminal theca in such a manner that the filum terminale is outlined throughout its length and the conus may be seen as a conical widening of the contrast outline at the upper end of the filum (Fig 3a) The contrast medium may however flow too rapidly upwards along the posterior wall of the theca to identify the conus if this structure lies in normal position and careful study of the prone views must always be made for identification of vessels on the anterior aspect of the spinal cord The anterior spinal artery can frequently be seen in routine prone



Fig 4a

Fig 4b



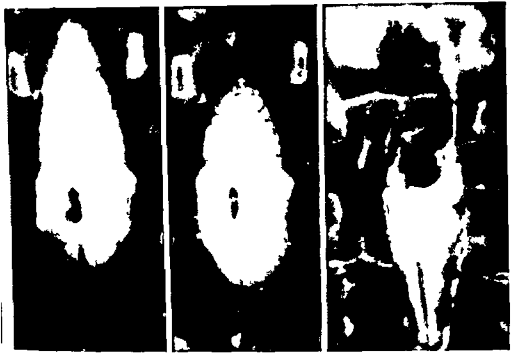
Fig 5

Fig 4 Male aged 9 years a) Apex of conus medullaris lies at level of upper border of L4 vertebra. b) At operation showing conus medullaris at level of L3 vertebra

Fig 5 Female aged 13 years supine myelogram Filum terminale measured 3 mm in width conus medullaris lies at upper border of L5 vertebra

myelography and in the region of the conus medullaris the anterior spinal vein may sometimes be identified as a slightly tortuous midline structure (Fig 3b)

The normal level of the conus medullaris at birth is at the upper border of *the body of L3* vertebra and in the adult the apex of the conus medullaris lies at the lower border of the body of L1 or upper border of the body of L2 vertebra There is no published information about the normal level of the conus medullaris during post natal growth but JAMES and LASSMAN (19[illegible]) suggest, from postmortem studies that the ascent of the spinal cord is normally completed at the latest by the end *of the fifth year of life,* at which age the conus medullaris normally lies at the level of the upper border of the body of L2 vertebra Thus if the conus medullaris is shown at myelography to lie at the level of the body of L3 vertebra or lower then this structure must be abnormally low placed



a b c

Fig 6 Myelograms of female aged 7 years a) Prone anterior spinal artery shown as midline linear outline cranial to oval filling defect formed by midline unossified septum at lower border of L3 vertebra b) Prone with slight alteration of tilt of table anterior spinal artery can be traced caudal to midline septum c) Supine conus medullaris is shown to lie caudal to filling defect caused by midline septum Septum is shown to be wider posteriorly than anteriorly on comparison with the prone myelogram

In the course of our research we have come to realise that the demonstration of an abnormally low placed conus is of extreme importance in assessing involvement of the spinal cord and cauda equina in the congenital anomaly either by anchorage by bands or adhesions, or by a midline septum associated with diastematomyelia or by pressure effects from an associated lipomatous mass or intrathecal dermoid Even in those cases in the series where no abnormality other than low position of the conus has been demonstrated within the theca at myelography subsequent operation has always disclosed a lesion in the region of the conus medullaris or cauda equina The myelographic appearance of a low placed conus medullaris is illustrated in Fig 4 a and at operation on this subject the low position of the termination of the spinal cord was confirmed (Fig 4b)

From a study of a series of apparently normal myelograms the maximum normal width of the filum terminale has been assessed to 2 mm However, if the conus medullaris is abnormally low in position the filum terminale often appears greater than 2 mm in width and at operation this has been



Fig 7 Male aged 4 years prone myelogram Anterior spinal artery can be traced as low as body of L5 vertebra and an oblique anterior medullary artery on left side is joining this vessel at level of upper border of L4 vertebra



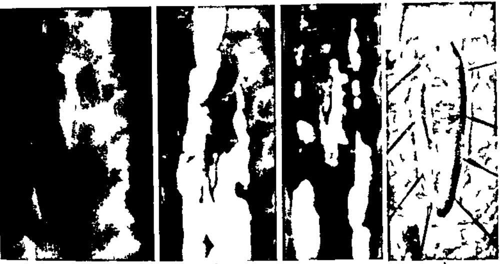
a b

Fig 8 Myelograms of female aged 1? years a) Prone small rounded translucency in centre of column of contrast medium at level of upper border of L3 vertebra b) Prone with slight alteration of tilt of table the small translucency remains constant (A fine fibrous septum was displayed at subsequent operation with diastematomyelia of the spinal cord)

found to be due to close adherence of some of the nerves of the cauda equina to the filum An example of the myelographic appearance of abnormal widening of the filum terminale is illustrated in Fig 5

Study of the anterior spinal artery The pre operative demonstration of the relationship of the lower end of the spinal cord to a clearly displayed developmental anomaly involving the spinal canal will assist in planning the surgical approach and technique Identification of the anterior spinal artery in the prone position inferior to the level of a midline septum, or demonstration of the conus medullaris in the supine position inferior to a midline septum, indicates involvement of the spinal cord in the developmental anomaly

An example is illustrated in Fig 6 In this case, tomography had shown no bony septum but the laminae were abnormal and inverted in the lower lumbar region and deficient in the lumbo sacral region, with widening of the interpedicular distances in the lower lumbar region Myelography in this case (Fig 6) demonstrated that an unossified midline septum was present cranial to the position of the low placed conus medullaris Diastematomyelia of the spinal cord must therefore exist in this case



a b c d

Fig 9 Female aged 10 years a) Coronal plane tomography showing outline of midline bony septum in spinal canal b) Prone myelogram the division of the column of contrast medium follows contours of ossified septum c) Supine contrast medium lying posteriorly within the theca again closely follows contours of ossified septum d) At operation the cut edges of the dura around the ossified septum are shown to be closely investing this structure extensive diastematomyelia right half of spinal cord appears compressed at level of septum

The obliquely placed extraspinal arteries reinforcing the anterior spinal artery may frequently be observed in the study of normal prone myelograms GILLIGAN, in an anatomical study, suggests that these vessels be termed the anterior medullary arteries Their number varies from seven to ten throughout the length of the anterior spinal artery, and the largest vessel the great anterior medullary artery, joins the anterior spinal artery at the lumbar enlargement of the cord usually from the left side These contributory vessels are seldom paired at any level, and, when seen, may assist in the identification of a low placed anterior spinal artery In the case illustrated (Fig 7) there was no evidence of a midline septum throughout the spinal theca at myelography but the appearance of the abnormally low placed anterior spinal artery was confirmed by the demonstration of a low placed conus medullaris in the supine examination Operation on this case revealed a fibrous band anchoring the spinal cord and preventing its normal ascent

Diastematomyelia with unossified septum A careful search must be made throughout the cervical, thoracic and lumbar regions of the theca for the presence of a midline septum within the spinal canal Such a septum may be fibrous cartilaginous or bony and if discovered at a level above the conus medullaris it will indicate the presence of sagittal division of the spinal cord at the same site Sagittal division of the spinal cord or diastematomyelia may exist without the presence of a dividing septum but the demonstration of a septum at myelo



a



b

Fig 13 Male aged 2 years a) Prone myelogram smooth rounded intrathecal mass at level of L4 vertebra with laminal defect in L5 vertebra b) Prone myelogram lateral view the mass lies posteriorly within the theca

Traction bands Traction bands passing from the spinal cord to the dura may not be demonstrable at myelography, but may sometimes be seen as single or multiple translucencies within the contrast medium in the supine myelogram A traction band may be differentiated from a septum dividing the spinal canal as the former will only be visible in the examination of the posterior wall of the theca in the supine position whereas a midline septum can be demonstrated as a filling defect in the contrast medium in both prone and supine positions In the case illustrated (Fig 11) a midline unossified septum was shown above the level of the conus medullaris and the small rounded translucencies lying immediately cranial to the septum in the supine myelogram were subsequently confirmed at operation as traction bands passing posteriorly from the spinal cord to the dura

Space occupying masses Failure of complete development in the median dorsal plane may be associated with an intra thecal or extra thecal lipomatous mass In the case illustrated (Fig 12) the spinal cord is clearly demonstrable as low



Fig 14 Same case as in fig 13 at operation The dura has been opened and an intrathecal dermoid cyst is displayed The intact dermal sinus is retracted towards right in the view

as the upper sacral region and the large oval filling defect in the contrast medium within the theca in the midsacral region was subsequently shown at operation to be an intrathecal lipoma with the spinal cord closely adherent to the lipomatous mass

Intrathecal or extrathecal dermoid cysts may occur in association with anomalous development in the median dorsal plane COWIE (1952) describes a case of intrathecal dermoid in which an ossified midline septum associated with diastematomyelia was present at a higher level within the spinal canal In the case illustrated (Fig 13) the patient presented with a history of recurrent meningitis, and a dermal sinus was discovered in the midline in the lumbo sacral region on clinical examination Survey radiography revealed a wide laminal defect in the 5th lumbar vertebra A pre operative diagnosis of an intrathecal dermoid cyst was made and was confirmed at subsequent operation (Fig 14)

Discussion

In the myelographic assessment of occult forms of spinal dysraphism the the radiologist is presented with an intricate and sometimes difficult examination usually on a child in which speed is essential to avoid undue irradiation of the patient The appearance and behaviour of the contrast medium within the theca are often bizarre at first sight on fluoroscopy and it is im

portant to obtain the essential information for assessment by following a strict routine. The following points should receive priority in the examination:

1. Exclusion of an Arnold Chiari deformity by upper cervical examination.
2. Detection of any space occupying mass within the spinal canal either intrathecal or extrathecal.
3. Detection of any midline septum or division of the meninges into two separate tubes.
4. Identification of the level of the conus medullaris.
5. Detection of any bands or adhesions passing from the spinal cord or cauda equina to the dura mater.

An Arnold Chiari deformity has not been demonstrated in this series of cases of occult spinal dysraphism; examination of the upper cervical region at myelography in thirty two consecutive cases (subsequently proven at operation to have an abnormally low placed conus medullaris, associated with a lesion involving the spinal cord or cauda equina) failed to show any evidence of descent of the cerebellar tonsils or the hindbrain. In patients exhibiting a meningomyelocoele, a form of overt spinal dysraphism, an Arnold Chiari deformity is frequently found to co exist, but in the occult forms of spinal dysraphism examined in this series the deformity has not been present.

NEUHAUSER, WITTENBORG and DEHLINGER quote twelve cases of transfixion of the neural axis by a midline septum, in one of which there was co existing hydrocephalus secondary to an Arnold Chiari deformity; it is not stated by these authors, however, whether this case exhibited an overt form or occult form of spinal dysraphism.

SANDS and CLARK suggest that an Arnold Chiari deformity may develop if a transfixing spicule in the spinal canal is demonstrated by radiologic studies, but in this present series the older children with a proven midline septum transfixing the spinal cord showed no myelographic evidence to suggest a developing descent of the cerebellum or hindbrain, although the conus medullaris was demonstrated in an abnormally low position in all these cases. The co existence of an Arnold Chiari malformation with certain forms of overt spinal dysraphism is therefore unlikely to be associated with mechanical traction upon the spinal cord during the growth of the foetus or child.

An apparent increase in the distance between the posterior surfaces of the vertebral bodies and the anterior aspect of the theca in the lumbo-sacral region seen in the lateral projection at myelography, has not been an uncommon finding in the cases in this series with a proven low position of the conus medullaris.

LOVE, DALY and HARRIS describing 'tight filum terminale' in three siblings found on air myelography that the gas was displaced posteriorly at the lumbo-sacral junction in two of the three cases. JONES and LOVE had previously illustrated an air myelogram showing this apparent posterior displacement of the theca in a case of 'tight filum terminale'.

In the experience of the author with positive contrast myelography, however, some apparent increase in the distance between the posterior surfaces of the vertebral bodies and the anterior aspect of the theca may exist normally in children in the lumbo sacral region presumably due to the presence of epidural fat and this finding has therefore not been regarded as positively significant in the absence of a demonstrable low position of the conus medullaris

In the presence of a *midline septum within the spinal canal*, BLIGH points out the value of myelography in assessing the extent of the division of the meninges into two meningeal tubes, which may be of great importance in planning the extent of the operation field The length of the diastematomyelia of the spinal cord in these cases cannot be assessed by our present methods of myelography, but it would appear that the division of the meninges may be the important factor in causing the progressive nature of the neurologic deficit in the presence of a midline septum associated with longitudinal division of the spinal cord in the growing child

BLIGH states that the osseous cartilaginous or fibrocartilaginous septum attached anteriorly to the body of one or more vertebrae may either lie free posteriorly or be attached to a neural arch In our experience in this series under review, the fourteen cases with a demonstrable midline septum associated with diastematomyelia showed attachment of the septum to the neural arch or dura posteriorly in every case

Except in the early cases in this series, tomography has been employed prior to myelography only in those cases where an irregularly ossified or faintly ossified midline septum has been detected in the survey views of the vertebral column In such cases the overall extent of the bony element of the septum can be compared with the extent of the division of the meninges at myelography Tomography has not been employed in order to search for a bony septum, not identifiable by survey radiography as myelography offers so much more radiologic information

The oily nature of the contrast medium employed has caused difficulty in detail interpretation of the myelographic appearances in some cases due to the occasional fragmentation of the medium into droplets Emulsification of the contrast medium in cerebrospinal fluid before introduction into the subarachnoid space according to the method described by BLEASEL would appear to be a major technical advance We are experimenting with this technique of positive contrast myelography and our early results in the detailed demonstration of the filum terminale and the conus medullaris by this method are encouraging

No attempt has been made in this paper to analyse the clinical material as reports on the clinical aspects of occult spinal dysraphism are appearing elsewhere (JAMES and LASSMAN) Early diagnosis in the growing child even before evidence of a neurologic deficit would be the ideal but the majority of the patients will primarily be referred from orthopaedic and child health

centres after the onset of physical disability, and, judging from experience at this centre, as the nature of this developmental lesion becomes more widely appreciated, the number of patients referred for investigation will increase

Acknowledgements

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SUMMARY

The appearances at pre operative myelographic examination of a series of cases with involvement of the spinal cord and cauda equina in developmental anomalies due to failure of complete development in the median dorsal plane are discussed The method of positive contrast myelography is described and detailed interpretation of the appearances is illustrated by examples

ZUSAMMENFASSUNG

Das praoperative myelographische Bild bei einer Reihe von Fallen mit Entwicklungsanomalien des Ruckenmarks und der cauda equina als Folge von Entwicklungsstorungen des medianen dorsum wird besprochen Die Methode der positiven Kontrast Myelographie wird beschrieben und eine detaillierte Interpretation des Bildes an Hand von Beispielen illustriert

RÉSUMÉ

L auteur étudie les aspects myélographiques pré opératoires d une serie de cas ou la moelle et la queue de cheval participaient aux anomalies de développement du plan médian dorsal L auteur décrit la méthode de myélographie et donne des exemples de l interprétation détaillée de ces aspects

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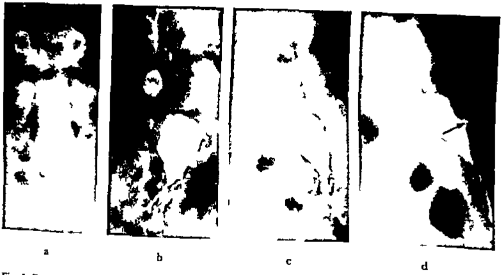


Fig 1 Positive contrast myelographies a) Water soluble medium Enlargement of dural sac al ence of the nerve roots constituting the cauda equina b) and c) Oily medium Relationship of dural sac with wall of vertebral canal d sclosed root sleeves present on the left side no root sleeves evident on the right d) Oily contrast medium lateral view Occult meningocele present

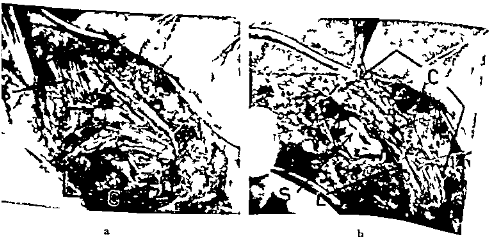


Fig 2 a) Non ascended cord (C) s en f om the left d ssected f om the fatty tissu in the sacral region explaining the absence of the cauda equina (cf fig 1a) Sacral oots (S) consistent with root sleeves n the left side (cf. fig 1b) b) Non asc nt of cord (C) seen f om the right (cf. fig 1c) absence of sacral roots (S) c onfirm ng myelographic findings The cran al d ect on of lumbar nerve roots (L) is caused by the arrest of the cord in the sacral region

left side but were totally absent on the right side (Fig 2b) A cranial direction of the lumbar nerve roots caused by the arrested cord in the sacral region was apparent The filum terminale was freed and the patient made an uninterrupted recovery On the fourth day following the operation control of micturition was gained for the first time

SUMMARY

The myelographic appearances in a case of occult dysraphism associated with spina bifida and non ascent of the cord are described

ZUSAMMENFASSUNG

Das myelographische Bild eines Falles von okkulter Dysraphie mit Spina bifida und verzogertem Aufstieg des Ruckenmarkes wird beschrieben

RÉSUMÉ

L auteur décrit les images myélographiques dans un cas de dysraphie occulte avec spina bifida et non ascension de la moelle

CENTRE MEDICO-CHIRURGICAL FOCH SURESNES PARIS, FRANCE

LA TOMOMYELOGRAPHIE CERVICALE HAUTE TRANSVERSALE

par

E Hertzog

Il ne fait pas de doute que l exploration du segment cervical du canal rachidien est le domaine d election de la pneumomyélographie fractionnee

La moelle cervicale y est toujours parfaitement visible depuis la jonction cervico dorsale jusqu a la hauteur de C3 C2 et il suffit pour mettre en evidence l ensemble de l espace sous arachnoidien cervical d examiner le malade en procubitus et en decubitus

Peu de modifications de la moelle elle meme peu de tumeurs extramedullaires peu de protrusions discales pensons nous ne sauraient echapper a ce niveau a un examen bien conduit, completé au besoin par une tomographie sagittale

Par contre nous avons a maintes reprises eprouve des difficultes lorsqu il s agissait de mettre en evidence une lesion medullaire ou paramedullaire des deux premiers segments cervicaux et bien plus encore une lesion tumorale ou autre de la region du trou occipital

La myelographie à contraste positif tel le Myodil ou le Lipiodol n etant pas exempte d inconvenients ne serait ce qu en raison du risque d innondation de la citerne basale et de l obligation de la soustraction ultérieure du produit de contraste nous avons essaye de parfaire si possible la technique de la pneumomyelographie cervicale et d obtenir d elle par des artifices de technique radiographique un complement d information sur la region que nous explorions

C est ainsi que des coupes tomographiques transversales au cours de la pneumomyélographie cervicale nous parurent éventuellement susceptibles de nous fournir des images complétant utilement celles de la tomographie sagittale et frontale Pour y parvenir il nous fallait pouvoir controler efficacement la répartition de l air autour de la moelle cervicale et effectuer rapidement les coupes tomographiques dans la position souhaitée

Dans un premier temps le malade est confortablement assis dans un fauteuil entierement mobile, a dossier rabattable et réglable en hauteur Apres ponction lombaire, ce dossier est ramené au contact du dos du malade assurant le maintien de ce dernier Il permet par construction de laisser en place l aiguille de ponction Le malade prend d'autre part appui par le front sur une teuere disposée de façon a obtenir une position optima de la colonne cervicale. L injection de 40 ml d'air est obligatoire pour obtenir dans cette position des images interprétables de la moelle cervicale Nous en controlons l ascension progressive dans les espaces sousarachnoidiens grace a l utilisation d un amplificateur de brillance L'image medullaire de profil est suffisamment nette et lumineuse pour qu'on perçoive parfaitement en scopie amplifiée les battements de la moelle, et les cliches pris ne nous fournissent guere de renseignements que l examen direct au binoculaire ne nous eut déja révélés

Cette partie de l examen termine, le malade est ramene en decubitus dorsal simplement par une rapide manœuvre amenant la tete en déflexion Apres un examen des espaces sous arachnoidiens prémedullaires le fauteuil est approché du tomographe et le malade mis en place

Ces changements successifs de position ont toujours eté mieux tolérés par le malade que nous n osions l esperer En effet, s ils sont effectues avec precision et rapidité, l air n a que peu tendance a envahir les citernes de la base et ceci d autant moins qu il existe au niveau de la moelle cervicale un processus pathologique s opposant à son ascension

Nous disposons d un tomographe vertical a effacement unidirectionnel Cet appareil qui fonctionne selon le principe de Vallebona Bozzetti sujet et film mobiles, foyer fixe, nous avait fourni d excellentes coupes osseuses axiales de la région du trou occipital et des trois premieres vertebres cervicales Nous pouvions donc esperer obtenir dans la meme région une tomomyélographie selon les memes plans de coupe Il suffisait de trouver pour le malade une position stable repondant a la fois aux conditions indispensables a l obtention de coupes tomographiques sous les incidences désirees, et au maintien dans les espaces sous-arachnoidiens cervicaux d une quantité d air suffisante

Le malade est installé en position semi allongee, le dos bien appuyé, les pieds cales Le craniostat occipital reçoit la tete en hyperextension L'aiguille de ponction lombaire pouvant jusqu'au dernier moment rester en place grace a la forme du dossier il est toujours possible d insuffler en supplément une petite quantite d air pour compléter au besoin le contraste myélographique meme apres lecture de la premiere coupe



Fig 1 Cas 1 Tomomyelographi de profil

Une fois le malade en place le tube est amene en position fixe a 1,50 metre du film Le faisceau roentgen est centre, la tete en extension de façon a aborder les corps des trois premieres vertebres cervicales et le trou occipital selon leur plus grand developpement axial, au besoin en faisant varier, suivant la hauteur de la coupe l inclinaison du rayon sur l horizontale

Nous avons tout d abord procéde a des examens, selon cette méthode chez des malades pour lesquels l histoire clinique permettait de prevoir des images tomographiques normales ou presentant des modifications facilement identifiables

Premier cas Il s agissait d un malade qui nous avait été adressé par un hopital voisin avec le diagnostic de syringomyélie L epreuve de Queckenstedt avant cependant fourni une courbe un peu aplatie et l albuminorachie étant de 0 64 g nos collègues désiraient avoir la preuve de l absence de toute tumeur Les coupes tomomyélographiques de profil montrent parfaitement la moelle cervicale depuis C1 jusqu à C7 Le renflement cervical apparait très nettement avec dans ce cas (Fig 1) son maximum au niveau de C5—C6 Au dessus, la moelle va en s amincissant Le prolongement cervical de la grande citerne est libre On interprète cependant difficilement les images medullobulbaires de la région de la charniere occipito-cervicale

Par la tomomyélographie cervicale haute axiale nous avons obtenu des images facilement interprétables qui nous ont paru confirmer l absence d une tumeur extramédullaire

Le cliché de la coupe axiale réelle au niveau de la troisième cervicale (Fig 2a) montre la vertebre pratiquement en totalité le corps en avant les apophyses articulaires l arc postérieur avec son apophyse epineuse délimitant le canal rachidien L air y entoure la moelle d une enveloppe de contraste négatif qui fait ressortir ses contours avec une nettete parfaite Sur la face anterieure on remarque l ébauche du sillon médian La section médullaire est de moyenne importance l espace sousarachnoidien bien développe parait parfaitement libre et continu Du contour postero-lateral droit de la moelle part une ombre tendue en direction de la paroi du canal rachidien Il s agit probablement d un groupe radiculaire posterieur

A un niveau a peine supérieur a l articulation de la troisieme vertèbre cervicale et de l axis environ les rapports entre la moelle et le canal rachidien apparaissent avec plus de netteté encore (Fig 2b) La section médullaire est ici etalée transversalement On remarque toujours la dénivellation du sillon médian anterieur Latéralement des deux cotés l aspect effilé de la section médullaire situe l insertion continue du ligament dentelé La petite ombre arrondie postérieure est peut être une section vasculaire sans que nous ne puissions l affirmer Il se peut aussi que cette image avec les deux autres claires qui la bordent traduisent l existence d une cavite syringomyélique

La coupe suivante (Fig 2c) celle de l anneau atoidien se caractérise du point de vue

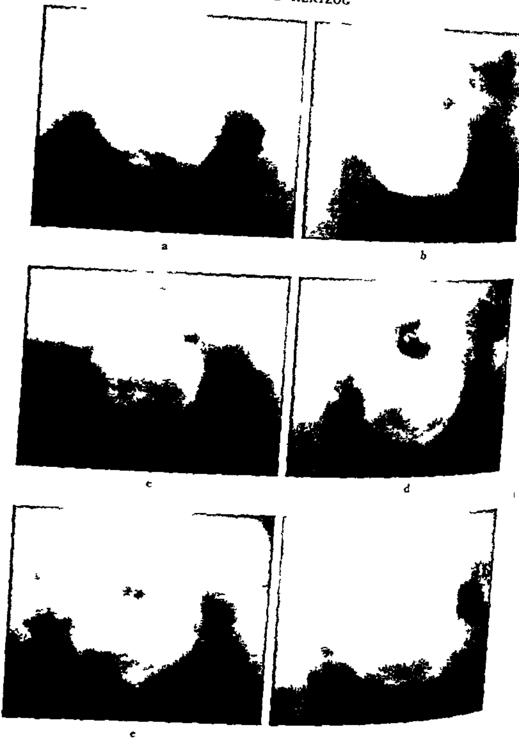


Fig 2 Cas 1 Tomomyélographie Coupes axiales a niveau C3 b) niveau C2–C3 c) niveau C2 d) niveau C1 e) occipito-atloïdienne f) niveau du trou occipital.



Fig 3 Cas 2 Myelographie cervicale profil Espaces sous-arachnoidiens antérieurs

osseux par la volumineuse apophyse épineuse la base de l apophyse odontoide facilement reconnaissable les apophyses latérales

Une quantité relativement importante d air baigne ici la moelle qui apparait parfaitement isolée dans le canal On ne découvre sur le cliché comme unique accident que l ébauche d un groupe radiculaire gauche

Sur le plan de l atlas (Fig 2d) dont les masses latérales ainsi que la coupe franche de la dent de l axis signent le niveau on remarque à droite le trou transversaire et meme la gouttière de l artere vertébrale sur la face superieure de l arc posterieur La moelle est plus volumineuse de section presque régulièrement arrondie elle occupe pratiquement tout l espace entre l odontoide et l arc postérieur L espace sous-arachnoidien est reduit Nous nous trouvons ici à la jonction medullo-bulbaire

A la charniere occipito-atloidienne nous obtenons une coupe franchement bulbaire (Fig 2e) La forme bi mamelonée du bord antérieur de l image ne laisse subsister aucun doute quant à son appartenance au bulbe ce sont les pyramides antérieures que moule une mince couche d air Le bulbe est a plein dans l espace disponible mais il y est seul Aucune ombre parasite ne l accompagne il n y a pas de tumeur

A la hauteur du trou occipital et immédiatement au dessus de lui a la base meme de la fosse posterieure nous atteignons le plan correspondant à la protubérance (Fig 2f) Le cliché en coupe axiale reproduit en effet tres exactement la disposition topographique de la région La coupe montre en arriere tout contre le bord postérieur du trou occipital deux petites ombres mamelonées les amygdales cérebelleuses En avant le long du bord antérieur la masse importante de la protubérance dans son tiers inferieur occupe une bonne moitié de l espace disponible et déborde en arriere de chaque coté

Entre protubérance et amygdales cérebelleuses existe une cavité grossierement triangulaire à base antérieure et sommet postérieur Il s agit de l entonnoir qui a partir de la grande citerne conduit vers le trou de Magendie Nous sommes donc en presence d une coupe axiale de la Valécula

Au centre de l image qui lui correspond apparait une clarté plus prononcée qui est vraisemblablement la partie la plus basse du quatrieme ventricule Protubérance amygdales cérébelleuses sont dans leur ensemble entourees d une mince lame d air sous arachnoidienne qui les *séparent des contours* osseux Nous pensons que ce premier cas nous a fourni des images normales

Deuxieme cas Cette malade que nous connaissons depuis deux ans deja nous a posé un problème diagnostique particulièrement épineux. Elle presentait une hemiplegie spasmodique gauche sans participation faciale et sans atteinte d aucun nerf cranien

Une ébauche de syndrome spinothalamique apparue au membre inférieur droit nous fit rejeter l hypothese d un syndrome de Mills et nous nous sommes mis a rechercher à nouveau une tumeur cervicale

La myélographie cervicale classique nous prouve la permeabilite parfaite de l espace sous arachnoidien le long des cordons postérieurs et le libre passage de l air dans la grande

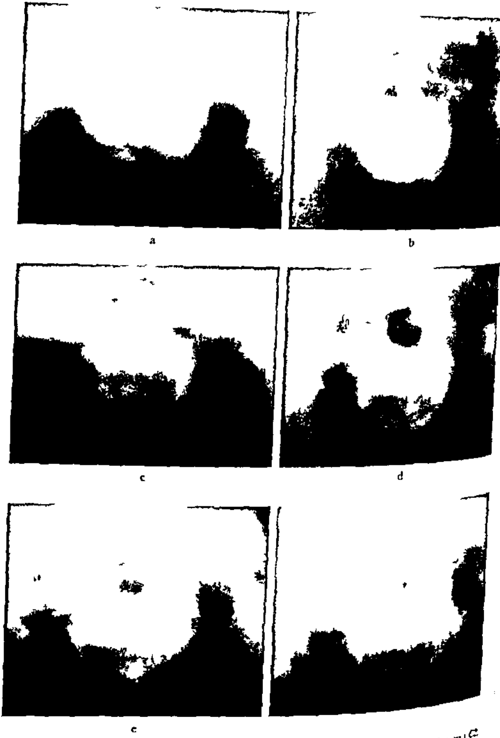


Fig 2 Cas 1 Tomomyelographie Coupes axiales a) niveau C3 b) niveau C2—C3 c) niveau C2 d) niveau C1 e) occipito atloidienne f) niveau du trou occipital



a b

Fig 6 Cas 3 Tomomyélographie Coupes axiales a) niveau C1 b) passant par le pôle de la tumeur

Sur le cliché de la coupe au niveau de C1 (Fig 6a) nous ne pouvons guère distinguer de détail à l intérieur du canal rachidien Celui ci paraît entièrement comblé tout au plus une fine image claire le long du bord droit du canal permet-elle de soupçonner la persistance d une perméabilité partielle de l espace sous arachnoïdien

Par contre la coupe axiale (Fig 6b) passant par le pôle supérieur de la tumeur révèle des détails que les clichés de profil ne fournissaient pas La tumeur est effectivement prémédullaire La moelle est plaquée en arrière et vers le flanc latéral droit du fourreau dural La tumeur tout en étant prémédullaire semblait donc s étendre également latéralement à gauche de la moelle L espace sous-arachnoïdien n était libre que le long du flanc antérolatéral droit du fourreau dural

A l intervention on découvrit effectivement un méningiome a insertion antérieure dont la topographie confirmait en tous points celle que la tomomyélographie transversale nous avait fait prévoir

Ces quelques documents qui sont parmi les premiers que nous possédons nous ont paru suffisamment prometteurs pour justifier et leur présentation et notre décision de compléter toute myélographie cervicale par une tomomyélographie transversale, chaque fois que nous soupçonnons l existence d une lésion a l intérieur du canal rachidien a la hauteur des trois premières vertèbres ou du trou occipital

Du point de vue technique nous ne pensons pas qu il y ait intérêt à amincir la coupe a l *extrême* car les coupes relativement épaisses nous paraissent nécessaires pour un examen tomographique ou tout repose sur le contraste entre l air sejournant dans les espaces sous arachnoïdiens et l opacité relative de la moelle et du bulbe En pratique nous avons réduit l angle de coupe à 35 degres et avec l appareillage que nous possédons une tension de 70 kV reels une intensité de 75 milliamperes et un temps de pose de deux secondes, nous permirent d obtenir les documents qui ont fait l objet de notre présentation

RÉSUMÉ

Cette méthode permet d obtenir de la moelle cervicale des images en coupe axiale complétant utilement celles fournies par la pneumographie classique Elle est utilisable de C 3 à la protubérance Les clichés montrent sous une incidence inusitée la moelle dans tous ses détails le bulbe les amygdales cérébelleuses la protubérance le quatrieme ventricule et la grande citerne Ils situent ces formations par rapport au canal rachidien et au trou occipital, en montrent la taille réelle et en visualisent les relations topographiques avec une éventuelle tumeur

SUMMARY

Transversal cervical tomomyelography produces axial sections of the cord and is a valuable supplement to conventional pneumography The region between C 3 and the pons may be examined by the method The unusual projections obtained display the medulla oblongata, cerebellar tonsils pons fourth ventricle and cisterna magna in detail The true size of these structures as well as their relations to the spinal canal and foramen magnum is shown and the topography of any tumour is demonstrated

ZUSAMMENFASSUNG

Transversale cervicale Tomomyelographie erzeugt axiale Schnitte durch den Wirbelkanal und ist zur ublichen Pneumographie eine wertvolle zusatzliche Untersuchungsmethode Mit dieser Methode kann die Gegend zwischen C 3 und der pons untersucht werden Die ungewohnliche Projektion die man hierbei erhalt gestattet die Detaildarstellung der medula obl der cerebellaren Tonsillen der pons des 4 Ventrikels und der Cisterna magna Es wird die wahre Grosse dieser Strukturen sowie auch ihre Beziehungen zum Spinalkanal und Foramen magnum gezeigt und die Topographie einer eventuellen Geschwulst dar estellt

FROM THE ROENTGEN DEPARTMENT OF THE NEUROLOGIC CLINIC, CHARLES UNIVER SITY PRAGUE CZECHOSLOVAKIA

MOBILITY OF THE THORACIC SPINAL CORD UNDER NORMAL CONDITIONS

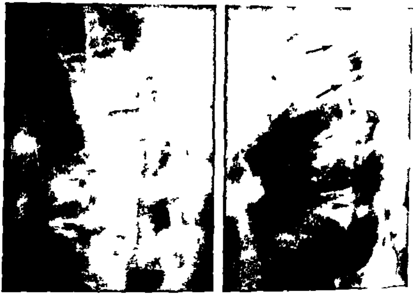
by

JAN JIROUT

Investigations performed with the aid of pneumography have shown that the position of the cervical spinal cord changes with the body posture moving forwards when the subject is prone and backwards when supine The extent of these movements measured in 200 normal subjects ranged between calculated mean values of 2 5 and 4 mm at the different levels of the cord and exceptionally reached 8 to 9 mm (JIROUT 1959)

It appeared probable to me that some movement may also occur in the thoracic region and this is the problem that formed the basis of the investigation now reported LINDGREN (1951) observed that the caudal end of the spinal cord moves laterally as the subject takes up the right or left decubitus positions My endeavour has been to find out to what extent the thoracic spinal cord may be movable in the anteroposterior direction

In our first group of 86 subjects in which the pneumographic appearances of the thoracic spine were normal the movements of the spinal cord that occurred as the subject moved from the lateral to the prone posture were measured by noting the distance of the anterior margin of the spinal cord from the anterior wall of the spinal canal as shown in lateral films In 24 cases i e in about 28 % the spinal cord moved forwards in 4 cases the ventral displacement of the spinal cord caused the anterior arachnoid space to disappear



a b

Fig 1 a) Lateral position Normal anterior arachnoid space b) Prone position Spinal cord in upper thoracic region displaced forwards anterior arachnoid space narrowed (arrows)

(Fig 1), and in a further 4 cases measurement of the movement proved im possible The true movement of the thoracic part of the spinal cord in the remaining 16 cases corresponded to a calculated mean value of 1 05 mm In the 4 cases in which the anterior arachnoid space disappeared the average value was 2 7 mm There appears to be some relationship between the mobility of the thoracic spinal cord and the permeability of the posterior arachnoid space

In a second group of 114 normal subjects movement of the spinal cord was evaluated by measuring the distance of the anterior margin of the spinal cord from the wall of the spinal canal in lateral views obtained in supine and prone positions respectively Displacement of the spinal cord was observed in nearly all cases (Figs 2 and 3) The mean value of the true anteroposterior movement of the spinal cord in the midthoracic region was 2 08 mm (max 4 3 mm) The mobility of the lower thoracic spinal cord, as measured just above the lumbar enlargement, corresponded to a calculated mean value of 1 08 mm (max 5 5 mm) Movements of the lumbar enlargement anteroposteriorly are common findings and are about equal to those which occur in a lateral direction The mean value obtained in measurements in 16 subjects was 3 [illegible] mm (Fig 4)

The question arises as to whether the movements of the cervical and thoracic spinal cord are artefacts that appear only because a part of the spinal fluid has been replaced by air or whether the spinal cord also moves with changes



a b

Fig 2 a) Supine position Anterior arachnoid space widened b) Prone position Spinal cord displaced ventrally anterior arachnoid space narrowed and almost obliterated (arrows)



a b

Fig 3 a) Supine position Anterior arachnoid space widened b) Prone position Spinal cord displaced ventrally considerable narrowing of anterior arachnoid space (arrows)

in the position of the body if no air has been introduced LILIEQUIST (1960) noted that the cervical spinal cord moves to the ventral wall of the spinal canal during insufflation in pneumography and stated that the interpretation of this must be that this continuation of the medulla floats in cerebrospinal fluid and sinks forward when the fluid is replaced by air



a b

Fig 4 Changes in position of the lumbar enlargement
a) Supine position Anterior contour of spinal cord (arrows)
b) Prone position Posterior contour of spinal cord (arrows)



a b c

Fig 10 Anterior (→) and posterior (←) rows of droplets Conventional lateral films in supine (a) and prone (b) positions c) Pneumogram The anterior row of oil droplets corresponds to the posterior margin of the spinal cord The posterior row of droplets adheres to the posterior dural wall

the spinal canal Furthermore we observed these signs of adaptation only in subjects with good mobility of the spinal cord and found them absent in those cases in which there were only slight movements of the spinal cord (Fig 8) They were present in the cervical region as well (Fig 9) These observations may be considered as indirect proof of the fact that the movements of the spinal cord are not artefacts but that they occur also without insufflation of air We have also obtained direct evidence of such mobility, as proved by the following observations

Previous oil myelography in one case had produced two parallel rows of droplets of contrast medium in the thoracic region which in the supine position lay 2 mm apart (Fig 10a) and in the prone position were separated by 4 mm (Fig 10b) Pneumography revealed that the anterior row of droplets lay at the posterior surface of the spinal cord while the posterior row was adhering to the posterior wall of the dural sac (Fig 10c) The movement of the spinal cord was thus revealed without any air being introduced

In a further case a small row of oil droplets from a previous myelography could be identified close to the posterior arch of the atlas and corresponded to the normal position of the posterior surface of the spinal cord at this level Its distance from the arch of the atlas was 8 mm in the supine position and 10 mm in the prone position This finding proves that also the cervical spinal cord moves without any air having being introduced

Conclusions

1 It would appear that under normal conditions movement of the thoracic part of the spinal cord is as constant as movement of the cervical part It averages slightly over 2 mm and may exceed 4 5 mm

2 There is a relationship between the degree of mobility of the spinal cord and the air permeability of the posterior arachnoid space Good filling of the latter is usually associated with good mobility of the spinal cord

3 Movement of the spinal cord in an anteroposterior direction with changes in body posture is not produced by the introduction of air into the arachnoid spaces but in all probability occurs as a normal physiologic process

SUMMARY

Attention is called to the existence of changes in the position of the thoracic spinal cord according to the position of the body The results of the measurement of the movement of the thoracic part of the spinal cord in a material of 134 cases is reported It appears that the movement is a natural one and not produced for example by air injected at pneumography

ZUSAMMENFASSUNG

Es wird uber die Existenz der Bewegungen des thorakalen Rückenmarkes in Abhangigkeit von Lageveranderungen des Korpers berichtet Die Ergebnisse der Messung dieser Bewegung an Hand eines Materiales von 134 Fallen werden angegeben Es scheint dass die Bewegung naturlich ist und nicht durch Luftinjektion bei Pneumographie hervorgerufen wird

RÉSUMÉ

L auteur insiste sur l existence des mouvements de la moelle epinière thoracale en relation avec les changements postural du corp L auteur présente le résultat de la mesure du mouvement de la partie dorsale de la moelle épinière effectuée sur une série de 134 cas Il semble que ce mouvement est naturel et n est pas provoqué par l air injecté au cours de la pneumographie

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SERVICES DE RADIODIAGNOSTIC ET DE NEUROCHIRURGIE DE L INSTITUT J BORDET
BRUXELLES, BELGIQUE

MYELOGRAPHIE DANS LES INFILTRATIONS NEOPLASIQUES DE L'ESPACE EPIDURAL

par

G J MELOT, R POTVLIEGE, PH MARTIN et J BRIHAYE

L apparition de troubles neurologiques constitue l une des complications les plus redoutees des affections neoplasiques Elle entraine pour le patient un lourd surcroit d'invalidite et rend particulierement penible la période terminale de sa maladie La gravite de ces troubles justifie des mesures therapeutiques meme si celles ci ne peuvent etre que palliatives en ce qui concerne l'evolution de la neoplasie primitive Les medications hormonales ou chimiques introduites ces dernieres annees laissent entrevoir la possibilite d une action efficace dans le traitement des néoplasmes en generalisation Dans l etat actuel de nos connaissances et de nos possibilites, c est toutefois a la chirurgie ou a la radiotherapie qu il faudra recourir pour tenter de soulager un patient atteint d une compression medullaire Ces therapeutiques exigent un diagnostic precis tant de la situation des lesions dans le canal rachidien que de la nature de celles ci L experience indique en outre que le succes depend en grande partie de la precocite de l intervention Ainsi, depouillant en 1959 leurs resultats operatoires, BRIHAYE, SMETS et DE ROODE (1959) observent deux recuperations pratiquement totales survenues chez trois patients dont la paraplégie etait provoquee par une infiltration epidurale neoplasique, operes dans les premieres heures Par contre deux seulement de treize malades operes tardivement eurent une legere recuperation motrice Ce qui augmente encore l interet de ces resultats, c'est que les patients operes en urgence et

guéris de leurs troubles nerveux avaient présenté une paraplégie totale et flasque en quelques heures et qu'ils n'ont pas présenté de récidive au cours de leur survie qui a duré plusieurs mois.

Nous cherchons donc les structures dont l'atteinte par une néoplasie peut entraîner des complications médullaires. Envisageons tout d'abord le rachis et les méninges. La grande fréquence des métastases vertébrales est bien connue. L'os peut être envahi par contiguïté — c'est souvent le cas dans la maladie de Hodgkin — ou par transport à distance des cellules néoplasiques. BATSON (1957) a insisté à ce propos sur le rôle primordial du système veineux rachidien. La vertèbre elle-même peut aussi être le point de départ d'une tumeur maligne, d'un myélome par exemple.

L'espace épidural qui sépare l'os et les méninges est normalement rempli de tissus cellulo-adipeux et parcouru par des lymphatiques, des vaisseaux et des nerfs. Il peut être envahi par des coulées de tissu néoplasique provenant des vertèbres ou des régions paravertébrales au travers des trous de conjugaison. Dans d'autres cas, il l'est par des embols de cellules malignes charriées dans les lymphatiques ou dans les vaisseaux sanguins. Ici également les plexus veineux rachidiens et périrachidiens jouent un rôle des plus importants.

Le fourreau dure-mérien s'oppose en règle générale avec succès à la prolifération néoplasique qui tend à se répandre autour de lui sur une hauteur de plusieurs segments vertébraux.

L'espace sous-arachnoïdien, lorsqu'il est entrepris, est souvent colonisé en de larges étendues. Il en résulte une carcinomatose méningée qui peut être à la fois encéphalique et médullaire. DAGNELIE (1956) et BRUCHER (1960) en ont récemment relaté des exemples particulièrement démonstratifs. Dans d'autres cas, la tumeur sous-arachnoïdienne prolifère sur place et forme un nodule qui comprime les structures nerveuses adjacentes.

Des métastases peuvent se développer à l'intérieur de la moelle. Cette éventualité passe pour être extrêmement rare à l'opposé de ce qui se produit dans l'encéphale. La question si les métastases intra-médullaires demeurent inaperçues des cliniciens et des pathologistes peut être soulevée. WILLIS (1932) l'a suggéré et BENSON (1960) en a récemment décrit quelques cas personnels observés en peu de mois, ce qui lui a permis de porter de 21 à 24 le nombre des observations publiées dans la littérature.

Quelquefois, la prolifération néoplasique dans le système nerveux, dans les méninges ou dans le rachis ne permet pas d'expliquer de façon satisfaisante les complications neurologiques observées. Ceci a conduit différents auteurs à envisager d'autres mécanismes pathogéniques que la compression ou l'élongation de la moelle par l'action directe de la tumeur.

Parmi les multiples hypothèses avancées, la théorie la mieux étayée par les faits cliniques et par les constatations anatomiques insiste sur l'importance des lésions frappant les artères nourricières de la moelle. Quelquefois ces lésions vasculaires se produisent à distance des altérations médullaires. Il faut parfois

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les rechercher en dehors du canal rachidien et même de la colonne, au niveau des regions para aortiques par exemple GARCIN (1959) et ZULCH (1954) ont attiré l'attention sur la fragilite des zones médullaires situées a la limite des territoires de deux arteres segmentaires La disposition et le trajet de ces vaisseaux ont fait l'objet de travaux minutieux de la part de LAZORTHES (1956, et de son école ainsi que de GARCIN et de ses collaborateurs L un de nous (J B) avec FLAMENT DURANT et PERIER (1961) a récemment apporté plusieurs documents a l'appui de la pathogénie vasculaire des ramolissements médullaires dits symptomatiques

Ces diverses etiologies sont a considerer lorsqu'un patient atteint d un néoplasme développe une paraplegie L attitude therapeutique sera differente d'apres le diagnostic qui aura pu etre porté, l intervention chirurgicale est contre indiquée si le canal rachidien est libre de tout element compressif Les investigations cliniques et radiologiques doivent donc nous permettre de preciser de toute urgence le siege et la nature des lésions responsables des troubles que présente le patient

L exploration clinique approfondie a laquelle on aura recours en tout premier lieu demeure parfois insuffisamment précise dans ses conclusions lorsque la paraplegie est encore en voie d installation C est pourtant a ce moment que l intervention a le plus de chances d etre efficace avant que les lésions medullaires ne soient devenues irreversibles

La ponction lombaire complete les renseignements apportes par l examen clinique Un blocage pourra etre mis en evidence par mesure de la pression de l CR et par la manœuvre de Queckenstedt Ces explorations ainsi que les epreuves cytologiques et biochimiques pratiquees sur le liquide ne permettent cependant pas de déterminer le niveau de la compression

L examen radiologique du rachis procure de precieuses indications sur l état des vertebres On peut souvent en déduire certaines conclusions concernant le canal rachidien La concordance entre lésions osseuses et alterations médullaires est toutefois loin d etre absolue Nous voyons des patients atteints de gros délabrements squelettiques ne presenter aucun trouble neurologique et a l inverse, des paraplegiques avec des vertebres intactes Cela se produit lorsque la lesion responsable de la paraplegie est situee en dehors de la colonne ou lorsque l invasion du canal rachidien s est effectuee au travers d un trou de conjugaison Quelquefois l os est envahi mais son infiltration ne se manifeste pas sur les clichés Dans d autres cas, les foyers metastatiques sont masqués par des anomalies vertebrales telles que la spondylose déformante De plus, si les metastases sont multiples il peut etre difficile de déterminer celle qui provoque les troubles médullaires

Ces differentes éventualites expliquent que tres fréquemment on sera amene a verifier par myélographie l intégrite du canal rachidien C'est meme l une des principales investigations a pratiquer chez un paraplégique et, avec la ponction lombaire elle sélectionne les cas justifiables d une intervention

chirurgicale, elle indique de plus le siege précis de la compression Ceci permet de limiter au strict minimum la laminectomie dont les consequences au point de vue de la statique vertebrale peuvent etre sérieuses chez un patient déja atteint d une carcinomatose squelettique

Cet examen doit pouvoir etre effectué en urgence tout comme l est une angiographie carotidienne pour une lésion cérébrale aigue Il vérifie si le canal rachidien est libre et si ce dernier ne l est pas, il précise le siège de la tumeur, ceci permet d en deduire bien souvent la nature Il est bien connu par exemple que les compressions epidurales sont dans leur immense majorité d origine neoplasique, les épidurites inflammatoires etant nettement plus rares

D apres la classification généralement adoptée (LINDGREN 1957, CAMP 1950 LENZI 1954, BONTE et coll 1958) la tumeur peut etre localisee par la myélographie soit dans la moelle elle meme, soit dans l espace sous dural, soit encore dans l espace epidural C est aux infiltrations de ce dernier espace que nous consacrerons la suite de ce travail

Travail personnel

Nous avons eu l occasion ces dernieres annees d examiner 62 patients atteints d une affection neoplasique chez qui se sont developpes des troubles neu rologiques caracteristiques d une atteinte de la moelle ou des racines de la queue de cheval Chez 45 de ces malades il a eté possible de demontrer l existence d une infiltration epidurale Une myelographie a eté pratiquée à 39 d entre eux Comme 2 dossiers radiologiques n ont pu etre revus c est sur 37 observations que repose le present travail

Cette serie est assurement trop reduite pour que l on puisse en tirer des conclusions statistiques Signalons qu il est constitué par 13 femmes et par 24 hommes et que la repartition d apres l age est la suivante

En dessous de 20 ans	20—29 ans	30—39 ans	40—49 ans	50—59 ans	60—69 ans	Au delà de 69 ans
1	5	1	3	10	12	5

Le fait que la majorite des patients soit agés de 50 ans et plus s explique par la fréquence dans les memes decades des affections carcinomateuses L influence des lymphomes se manifeste dans la constitution du groupe de malades ages de moins de 40 ans 4 d entre eux sur 7 étaient atteints Chez 2 autres la biopsie ne permettait pas de se prononcer entre un lymphome et un carcinome indiffe rencié

Une grande diversite s observe a propos de la nature de la tumeur primitive L énumeration ci apres en fait foi C bronchique 5 C prostate 5 C estomac

3, lympho ou reticulosarcome 3, C rein 2, myelome 2, mélanosarcome oeil 2 lymphogranulomatose 2, leucémie 2, tumeur maligne indifferenciee 2, sa[illegible] ostéogenique 1, myélosarcome 1, fibroneurosarcome 1, C thyroide 1 C vessie 1, C sein 1, C parotide 1, C col utérin 1, tumeur non identifiee 1

Il est à remarquer que l infiltration épidurale a constitué chez 5 patients atteints de lymphome *la premiere et parfois meme la seule localisation clinique* de leur affection

Chez 7 autres patients, l'existence d une neoplasie etait ignoree avant que ne se developpent les métastases vertebrales ou epidurales L'un des cas les plus dramatiques que nous ayons observe est celui d un jeune homme atteint de leucemie aiguë chez qui il s etait forme une veritable tumeur epidurale comprimant la moelle dorsale avant que n'apparaisse le tableau clinique de sa maladie (MARTIN, MAGE, ROBERT 1960)

Chez 12 patients donc, soit 30 % de notre serie, l existence d une affection neoplasique etait ignoree avant le debut des troubles neurologiques Chez d'autres encore la notion d'une tumeur maligne pouvait etre suspectée mais n'etait pas demontree au moment de l hospitalisation

Le tableau suivant montre d apres leur localisation, les différentes lesions observees Lorsque celles ci s'etendaient a plusieurs vertebres, seul le niveau superieur a ete indique

Tableau

Ce tableau reflete la fréquence des localisations dorsales 26 fois pour les 12 vertebres thoraciques alors que la proportion est de 3/7 pour les vertebres cervicales et de 6/5 pour les lombaires

C1	C2	C3	C4	C5	C6	C7
—	—	1	—	—	—	2

D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12
1	5	1	1	1	5	2	3	1	1	4	1

L1	L2	L3	L4	L5	S
1	—	1	1	3	2

D apres la symptomatologie clinique nous relevons 28 paraplegies (70 %) et 9 syndromes de la queue de cheval (25 %)

Habituellement les atteintes de la moelle se sont manifestées brutalement ou en quelques jours Lorsqu'elles se sont presentées comme un "ictus médullaire", la verification operatoire ou nécropsique a montre qu elles résultaient de lesions vasculaires de la moelle Lorsqu elles etaient lentement progressives, les altérations medullaires s expliquaient par des phenomenes de compression La paraplegie etait en général precedee ou accompagnee de douleurs Sourdes *et profondes lorsqu'elles resultent* d une entreprise de la vertebre les douleurs prennent un caractere bien particulier lorsqu elles sont provoquees par

l irritation d une racine Ceci permet de determiner bien souvent le niveau segmentaire de la lesion Cinq de nos patients ont présente un syndrome d infiltration du plexus cervico-brachial avant le début des troubles moteurs Les autres ont souffert de douleurs en ceinture thoracique ou abdominale ou de sciatalgies Ces douleurs prémonitoires ont eu des durees variables allant de plusieurs mois a quelques heures

Nous observons dans les 5 syndromes du plexus cervico-brachial 2 epitheliomas bronchiques (tumeur de Pancoast), 1 carcinome gastrique 1 leucemie chronique 1 neurofibrosarcome Dans les syndromes de la queue de cheval, nous relevons 2 Ca de la prostate 2 reticulosarcome 1 neo du col, 1 Ca gastrique, 1 C du rein 1 C parotide et 1 tumeur maligne indifferenciee

Apport de la radiographie standard du rachis

Chez 25 patients (70 %) nous avons observe des lésions osseuses nettes Chez 7 (17 5 %) nous n avons pas pu en mettre en evidence Chez 5 (12,5 %) il existait des anomalies minimes dont l interpretation etait discutable

Les remaniements vertebraux observes se sont presentes comme des foyers d osteolyse ou de condensation osseuse ou encore en des foyers mixtes Un indice tres precieux non seulement de malignite mais d entreprise des parois du canal rachidien a ete l altération d un pédicule vertebral La valeur de ce signe a ete une nouvelle fois confirmee La vertebre infiltree etait quelquefois tassee ce qui avait entraine l angulation du rachis Si cette angulation était prononcee, on pouvait s attendre a une elongation de la moelle et a sa fragilite envers une compression epidurale additionnelle Tres souvent la metastase vertebrale faisait partie d un tableau de carcinomatose squelettique generalisee et l on retrouvait de multiples dépots secondaires par exemple dans le rachis les cotes et le bassin Il etait de regle d ailleurs qu a l intervention chirurgicale ou a l autopsie les alterations osseuses etaient plus importantes que ne le laissaient prevoir les radiographies

Dans plus de la moitie des cas nous avons observe sur les cliches du squelette des anomalies des tissus paravertébraux Chez 13 patients il s agissait d un fuseau thoracique Quelquefois, ce fuseau etait bilateral, exactement centre sur l infiltration epidurale Dans d autres cas il etait unilatéral ou se developpait de façon asymetrique au dessus et au dessous de la lésion Son etendue s est montree variable d un patient a l autre et chez un meme patient au cours de l evolution de sa maladie

Dans les cas ou le fuseau etait peu important et bien delimite nous avons constate qu il indiquait assez fidelement le siege de la compression epidurale Dans 4 cas d infiltration du plexus cervico brachial nous avons releve un obscurcissement du sommet de l hemithorax accompagne dans les syndromes de Pancoast typiques de l erosion des cotes des apophyses transverses et du bord lateral des vertebres

Chez 2 patients, nous avons observé la tuméfaction d'un psoas, il s'agissait pour l'un d'eux d'un sarcome musculaire qui se prolongeait le long du rachis jusqu'aux vertèbres thoraciques, traversait la ligne médiane et passait en D10-D11 au travers du trou de conjugaison La valeur localisatrice de la déformation du psoas ne s'est donc pas révélée de grande précision, la tuméfaction constituait néanmoins une indication suggestive

Il faut souligner le fait que 2 fois un fuseau paravertébral thoracique s'était manifesté sans qu'il y ait d'altération osseuse décelable ce qui augmentait d'autant son intérêt

Apport de la myélographie

Nous avons recours pour chacun de nos examens à la myélographie opaque Il nous a paru en effet que cette méthode était moins complexe à réaliser et moins pénible à supporter pour le patient que la myélographie gazeuse (Odés 1953) Le danger de provoquer d'éventuelles lésions d'arachnoïdite nous semble largement compensé par le bénéfice que retire le malade atteint d'un carcinome en généralisation d'un examen rapidement mené et dont les résultats prêtent peu à confusion (CAMP 1950)

Chez la plupart de nos malades, l'huile iodée (du Myodyl généralement) a été introduite par ponction sous occipitale Il nous semble en effet que le produit de contraste reste mieux collecté que lorsqu'il est injecté par ponction lombaire la bascule du patient est moindre elle est mieux supportée et la quantité de produit nécessaire est plus réduite, surtout si la compression siège au dessus du segment médio dorsal du rachis Nous n'avons jamais dépassé la dose de 3 ml alors que de nombreux auteurs (SHAPIRO 1961) utilisant la voie basse en injectent couramment 9 ou 12 ml Quelques examens ont cependant été pratiqués par voie lombaire soit seule, soit en association avec la voie haute et ce afin d'étudier le plus complètement possible l'état du canal rachidien

L'examen est effectué le patient se trouvant tout d'abord couché en procubitus sur la table basculante Ensuite, si l'état du malade le permet il est complété par un transit en décubitus afin de mieux définir la partie postérieure des espaces spinaux

La myélographie est bien entendu pratiquée sous le contrôle de la scopie et les lésions étudiées par des clichés répétés pris sous de multiples incidences (face, profil, obliques)

Résultats

Chez 30 de nos patients, la compression épidurale s'exerçait au dessus du cône médullaire chez 7 au dessous Les images radiologiques de la compression étaient typiques chez 35 patients (95 %) chez 2 seulement elles donnaient lieu à discussion

La caracteristique essentielle des infiltrations épidurales est d exercer leur poussee de la peripherie vers le centre du canal rachidien Les coulees sous arachnoidiennes de la substance de contraste sont amincies et déjetées vers le dedans tandis que l espace qui les separe des parois osseuses du canal rachidien est elargi Comme l infiltration neoplasique tend a se repandre en hauteur et en largeur autour du fourreau dural, son epaisseur est en géneral assez uniforme autour de la moelle Celle ci enserree par une virole de tissus néoplasiques demeure le plus souvent en place Elle est quelquefois refoulée en regard de l endroit ou la penetration de l espace epidural s est effectuee, la ou l epaisseur de la coulee neoplasique est la plus importante Dans ce cas la moelle efface de dedans en dehors les espaces sous arachnoidiens du cote opposé a la tumeur épidurale et a un niveau legerement different Un deplacement de la moelle a ete releve chez 9 patients, soit 30 % de ceux qui presentaient une localisation tumorale au dessus de la queue de cheval

L obstacle s est presque toujours revele infranchissable Dans 3 cas seulement, les gouttieres arachnoidiennes comprimees étaient demeurees permeables a l ecoulement de l huile iodee qui decrivait un arc de cercle dont la concavité était dirigee vers l exterieur Souvent le produit de contraste est encore parvenu a s ecouler sur plusieurs millimetres le long des faces antérieure ou posterieure de la moelle alors qu il était arrete dans les gouttières laterales Ceci entraine la formation d images en biseau plus ou moins irrégulieres et dentelees Dans d autres cas c etaient les gouttieres laterales qui demeuraient libres

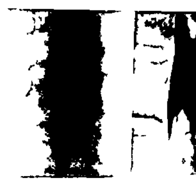
L examen nous a permis frequemment de reconnaitre l existence d altera tions medullaires bien connues des cliniciens et des pathologistes Ceux ci ont decrit au niveau de la moelle des reactions œdémateuses des hemorrhagies petechiales ou en nappe des necroses des infarcissements des ramolissements des formations kystiques Ces alterations entrainent une tumefaction de la moelle dans tous ses diametres Nous avons pu retrouver cette tuméfaction globale chez 10 de nos patients (27 %) L élargissement du cordon medullaire s il resulte d une simple compression apparait dans le seul plan perpendiculaire a celui dans lequel s exerce la poussée tumorale et dans lequel la moelle se revele alors amincie Nous avons observé 3 images d amincissement medullaire (9 % des cas) qui nous ont paru résulter d un etranglement par l anneau tumoral ou d une atrophie

Les vaisseaux disposes en lacis autour de la moelle sont quelquefois dilates et tortueux ce qui se traduit par des images myelographiques caracteristiques

Sous le cone terminal l infiltration epidurale prolifere sans etre genee par le cylindre médullaire L aspect sous lequel elle se manifeste se rapproche de celui qui resulte d une hernie discale si la compression tumorale s exerce d avant en arriere Le refoulement du sac dural s effectue toutefois en regard d un corps vertebral plutot que d un interligne Les gaines radiculaires ne s opacifient pas du cote de la lesion Parfois la compression s est revelee telle qu elle s opposait au remplissage du cul de sac qui apparaissait anormalement etroit et peu



Figs 1 et 2 Cas 1 Refoulement et compression de la moelle par une tumeur épidurale droite Prolongement postérieur de la tumeur épidurale tuméfaction de la moelle dans le seul plan sagittal



Figs 3 et 4 Cas 2 Arrêt du Myodil formant une image en biseau en D9 (image à gauche) Coulées antérieure et postérieure de la substance de contraste dejetées vers le centre du canal rachidien, tuméfaction de la moelle dans le seul plan sagittal (image à droite)

profond Comme l ont indique SHAPIRO et ses collaborateurs, une image semblable a celle ci se rencontre lors d'une anomalie de développement du sac dural L'existence de remaniements vertébraux oriente l interprétation des cliches Il en est de meme s'il existe des irrégularités et des asymetries dans les contours de l index opaque Inversément dans les cas ou il existe une brièveté congenitale du cul de sac l infiltration epidurale sera difficile à déceler elle s exercera sur les racines sans qu il y ait d altération manifeste a la myélographie

Observations

Cas 1 Un homme déja opéré d un liposarcome de la cuisse gauche subit une réintervention pour tumeur du psoas du même coté Dans les premiers jours post opératoires il développe une paraplégie flasque rapidement progressive dont le niveau n est pas encore fixé quand il est décidé de lui pratiquer une myélographie (Fig 1)

Il n y a pas de lésion osseuse certaine bien que les pédicules droits de D 10 et de D 11 paraissent moins bien définis que les gauches L examen révèle l existence d une compression épidurale droite refoulant la moelle contre la paroi latérale gauche du canal rachidien De face le diametre du cordon médullaire parait aminci De profil il est élargi Dans cette dernière incidence la coulée opaque postérieure est déjetée en avant (Fig 2)

L intervention pratiquée dans les 3 heures des premiers signes de paraplégie permet l ablation de tissus sarcomateux provenant des muscles des gouttieres et s engageant par les trous de conjugaison Le traitement chirurgical est completé par la roentgentherapie

La récupération neurologique est complète dans le mois qui suit la laminectomie elle s est maintenue pendant les 8 mois de survie qu a encore présenté le patient

Cas 2 Chez ce patient il s installe en quelques mois une paraplégie flasque dont le niveau clinique est en D 10 Il n y a pas de néoplasie primitive connue

La radiographie standard met en évidence une infiltration de D 12 avec fus au b la [illegible]

En D 9 cependant sans que la vertèbre paraisse altérée il existe une *légère* tuméfaction des tissus paravertébraux



Fig 5 Cas 3 Métastase épidurale d un sarcome osseux nfarcissement médulla re au niveau de l obstacle



Fig 6 Cas 4 Myelographie ascendante compression épidurale consécutive au developpement d une tu meur de Pancoast necrose at ophique de la moelle



Figs 7 et 8 Cas 5 Infiltration metastatique epi durale dont les signes rad ologiques sont moins accuses que ceux qui resultent de la tuméfaction secondaire de la moell

A la myelographie (Fig 3) le produit de contraste est arreté dans les gouttieres latérales alors qu il s ecoule encore de 1 cm environ le long des faces antérieure et postérieure de la moelle ce qui donne a l arrêt un aspect en biseau De profil (Fig 4) les coulees anterieure et postérieure de Myodil sont dejetées vers la ligne médiane Le cordon médullaire s élargit de façon manifeste dans le seul plan sagittal c est a-dire dans le plan perpendiculaire à la poussée tumorale la plus forte

La verification anatomique confirme le diagnostic de tumeur épidurale métastatique La moelle présentait des signes de demyélinisation cordonale typiques d une compression progressive et de longue durée Le neoplasme primitif était un carcinome de la vessie

Cas 3 Une jeune femme en traitement pour un sarcome du femur développe en une huitaine de jours une paraplégie flasque dont le niveau clinique se fixe en D 8 L examen osseux du rachis ne met pas de lésion en évidence

A la myélographie (Fig 5) arret total en D 3—D 4 typique d une infiltration épidurale Le cordon médullaire paraît moderément élargi dans tous ses diametres

L intervention chirurgicale est pratiquée au dixieme jour de la paraplégie Elle confirme la présence d une tumeur épidurale métastatique et d une tumefaction de la moelle qui est infarcie et incarcérée dans le canal rachidien Il ne s est pas produit de recupération après la laminectomie

Cas 4 Ce patient présentant une tumeur de Pancoast avec syndrome de Claude Bernard Horner et névrite cervico-brachiale développe une paraplégie flasque brutale survenue après des prodromes moteurs et douloureux dans le membre inf rieur gauch L examen du rachis révele l existence d une opacité apicale gauche avec structur sp cte des côtes et du bord gauche du rachis

La myélographie (Fig 6) met en évidence un arret par ompre ion epidurale en D 2 Le cordon médullaire est aminci

Le patient décède brusquement avant son transfert en n urochirurgie

A l examen post mortem la moelle est nécrotique de C 8—D 3 La compression épidurale paraît minime Dans les tissus paravertébraux on décou re une thrombose veineuse et arté rielle des vaisseaux segmentaires



Figs 1 et 2 Cas 1 *Refoulement et compression* de la moelle par une tumeur épidurale droite Prolongement postérieur de la tumeur épidurale tuméfaction de la moelle dans le seul plan sagittal



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Cas 2 Chez ce patient, il s installe en quelques mois une paraplégie flasque dont le niveau clinique est en D 10 Il n y a pas de néoplasie primitive connue

La radiographie standard met en évidence une infiltration de D 10 avec fuseau bilatéral *En D 9 cependant* sans que la vertebre paraisse altérée il existe une légère tuméfaction des tissus paravertébraux



Fig 5 Cas 3 Métastase épidurale d un sarcome osseux infarcissement médullaire au niveau de l obstacle



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Figs 7 et 8 Cas 5 Infiltration métastatique épidurale dont les signes radiologiques sont moins accusés que ceux qui résultent de la tuméfaction secondaire de la moelle

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La myélographie (Fig 6) met en évidence un arrêt par compression épidurale en D 2 Le cordon médullaire est aminci

Le patient décède brusquement avant son transfert en neurochirurgie

A l examen post mortem la moelle est nécrotique de C 8—D 3 La compression épidurale paraît minime Dans les tissus paravertébraux on découvre une thrombose veineuse et artérielle des vaisseaux segmentaires

pas toujours avec une certitude suffisante les renseignements requis par le chirurgien ou le radiothérapeute Quelquefois, les lesions neurologiques constituent les premiers signes de la neoplasie en généralisation que presente le patient La ponction lombaire si elle indique la presence d un obstacle a l ecoulement du liquide cephalo rachidien n'en precise pas le niveau

3 L examen radiologique standard apporte des renseignements precieux sur l etat du rachis et des tissus paravertebraux Les alterations des pedicules et les images en fuseau constituent des indices de localisation, présents dans la moitié des cas environ

4 La myelographie permet de deceler l existence d un element compressif responsable de la paraplegie ou du syndrome de la queue de cheval que presente le patient Elle selectionne les cas justifiables d une laminectomie et permet de reduire celle ci au minimum Cet examen doit pouvoir etre realise d urgence et dans des conditions aussi confortables que possible pour le malade

5 La caracteristique essentielle des images de compression épidurale est l'amincissement des coulees de substance de contraste de la peripherie vers le centre du canal rachidien Les images observees ne laissent habituellement planer aucun doute ni sur la localisation des lesions ni sur leur nature

6 Frequemment, le cordon medullaire est elargi a hauteur de la compression Cette tumefaction, si elle intéresse tous les diametres de la moelle, indique l existence d'un œdeme reactionnel, de phenomenes hemorrhagiques ou d une necrose Si la tumefaction se produit uniquement dans le plan perpendiculaire a celui dans lequel s exerce la poussee tumorale, elle s explique par la compression et par l etalement de la moelle qui en resulte

7 La tumefaction médullaire par son importance suggere quelquefois l existence d une lesion intraparenchymateuse Dans d autres cas le neoplasme detruit la dure mere et en proliferant en dedans de celle ci produit a la myelographie des images lacunaires semblables a celles qui resultent du développement des tumeurs sous durales classiques

8 La compression du sac dural en dessous du cone medullaire se manifeste sous des aspects voisins de ceux que produisent les hernies discales La coexistence de lésions osseuses de type metastatique est un argument en faveur du diagnostic d infiltration epidurale maligne Quelquefois la mise en évidence des lesions sera rendue difficile par le faible développement du cul-de-sac lombosacre Cette anomalie ne doit pas etre confondue non plus avec une compression extra dural celle ci produit d[illegible] [illegible]gularités de contours qui n[illegible] s observent pas en ca[illegible] [illegible]iations anatom[illegible]

9 Ce n est bien s[illegible] [illegible]e par la conf[illegible] [illegible]on des résultats de l examen clinique, de l examen [illegible]ique standa[illegible] [illegible]chis et de la myélographie qu il sera possible [illegible]n diagnosti[illegible] de compression épidurale et de choisir [illegible] therapeuti[illegible] convenant [illegible] appliquer au patient Seu[illegible] [illegible]es divers diagnost[illegible] et curatives permet d'es[illegible] [illegible]e sur les [illegible]urolo[illegible]

RÉSUMÉ

La myélographie permet de définir avec plus de précision que la radiographie standard les infiltrations néoplasiques de l'espace épidural surtout au moment ou la symptomatologie clinique est encore en voie d'installation. Elle doit être effectuée en urgence afin de permettre un traitement chirurgical ou radiologique précoce. Habituellement les signes radiologiques recueillis sont typiques. Quelquefois ils présentent des particularités qui indiquent un envahissement sous-dural ou des lésions médullaires.

SUMMARY

Myelography enables a more accurate definition than conventional roentgenography of infiltrations in the epidural space, particularly when the clinical signs are progressing. It should be performed as soon as possible with a view to early surgical or roentgen treatment. The roentgenologic appearances are usually typical but sometimes include signs that indicate subdural invasion or medullar lesions.

ZUSAMMENFASSUNG

Myelographie ermöglicht eine genauere Darstellung von Infiltrationen des epiduralen Raumes als die gewöhnliche Röntgenaufnahme, im Besondern wenn die klinischen Symptome progredieren. Die Untersuchung sollte mit Hinblick auf frühzeitige chirurgische und Strahlentherapie sobald als möglich vorgenommen werden. Das Röntgenbild ist gewöhnlich typisch, ausser wenn die Anzeichen von subduraler Invasion oder medullären Veränderungen vorliegen.

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ONTGENINSTITUT (H J NIDECKER) UND FILMDIENST (HS R RICHTER) DER NEURO-
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RÖNTGENKINOMATOGRAPHISCHE UNTERSUCHUNGEN MIT POSITIVEN UND NEGATIVEN KONTRASTEN IM WIRBELKANAL

von

Hs R Richter und H J Nidecker

Die Verwendung des elektronischen Bildverstarkers hat sich fur die beson deren Bedurfnisse der neuroradiologischen Abklarung im Spinalkanal in den letzten 5 Jahren fur unsere gemeinsamen Fragestellungen ausserordentlich bewahrt Zudem ist es mittels der rontgenkinomatographischen Dokumentation moglich geworden sonst nur der Betrachtung durch den Durchleuchter zu gangliche Vorgange im Wirbelkanal festzuhalten und die Filme fur didaktische Zwecke zu verwenden

Apparatemassig wurde ein 5 Zoll (13 cm ∅) und ein 9 Zoll (23 cm ∅) Philips Bildverstarker verwendet welcher an einem Routineuntersuchungs gerat (Kipptisch) montiert war Die Filmaufnahmen wurden auf 35 mm mit der Arriflex Rontgenkamera aufgenommen und in 16 mm Reduktionskopien beurteilt

Als besonderer Vorteil hat sich die rontgenkinomatographische Dokumenta tion auch im Hinblick auf das Einsparen von Strahlen fur den Patienten erwiesen weil ein einmaliges Kippen und Passieren in einer pathologisch veranderten Region genugt um spater im Kinostreifen wiederholt beurteilt werden zu konnen

Die in unserer Demonstration zusammengefassten Beobachtungen beziehen sich sowohl auf Abklarungsuntersuchungen mit positivem Kontrast (Panto

paque, meist deszendierend im Wirbelkanal) als auch auf negativen Kontrast (Luft, aszendierend) zur Passagekontrolle in den diagnostisch besonders schwierig gelagerten Fallen von hochcervikalen Kompressionssyndromen und bei Missbildungen an der atlanto occipitalen Übergangsregion

An Hand einer Reihe von klinischen Fallen, wurden die Moglichkeiten der rontgenkinomatographischen Abklarung und Dokumentation bei Kontrastuntersuchungen im Wirbelkanal veranschaulicht Bemerkenswert erscheint vor allem die Verwendung der Technik in Fallen, wo sich die Frage stellt, ob d[illegible] *Kontrastmittel noch frei beweglich ist oder aber arachnitische Adhasionen zu* einer Fixation gefuhrt haben

Die herzsynchronen Pulsationen, resp von den Atembewegungen abhangige Druckschwankungen im Wirbelkanal wirken sich auf das Kontrastmittel aus sei es dass dieses im Wirbelkanal verschoben wird oder aber eine Niveauschwankung bei vollstandigen Passagehindernissen, bei *Husten* und *Pressen* auftritt

Ganz eindrucklich konnte nachgewiesen werden, wie im Falle von sakralen Wurzelzysten ein ventilartiger Mechanismus das Kontrastmittel innert Minute aus dem Duralsack in die symmetrisch ausgebildeten Zysten austreten lasst und ein Reflux in den Duralsack nicht mehr zustande kommt

Auf der andern Seite hat auch die rontgenkinomatographische Untersuchung, d h die funktionelle Abklarung bei einem Totalstop bei Diskushernie und Spondylolisthesis L4—L5 versagt, obschon das Kontrastmittel innerhalb *Minuten in die paraspinalen Weichteile* ausgetreten ist Wir konnten keine eigentliche Austrittsstelle nachweisen, auch nicht bei der nachfolge den Operation

Die negative Kontrastuntersuchung mit Luft hat sich uns vor allem bei der Abklarung von Fallen mit atlanto occipitalen Missbildungen, resp hochcervikalen *Passagehindernissen bewahrt Wir mochten die* Abklarung mit aufsteigender Luft fur solche Falle als die Methode der Wahl betrachten und die rontgenkinomatographische Dokumentation als statischen Bildern ausgesprochen uberlegen Herzsynchrone Pulsationen der Luft Liquorgrenze und der Medulla, resp der dorsalen und ventralen Luftsaulen sind besonders eindrucklich nachzuweisen gewesen

Neben der Erleichterung der diagnostischen Arbeit, ist die rontgenkinomatographische Dokumentation fur didaktische Zwecke als nicht mehr entbehrlich zu betrachten

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ZUSAMMENFASSUNG

An Hand einer Reihe von klinischen Fällen wurden die Möglichkeiten der röntgenkinomatographischen Abklärung und Dokumentation bei Kontrastuntersuchungen im Wirbelkanal veranschaulicht. Die Verwendung des elektronischen Bildverstärkers hat sich für diese Zwecke ausserordentlich bewährt.

SUMMARY

The possibilities of the diagnosis and documentation by means of roentgen cinematography as applied to myelography of the spinal canal were demonstrated in a number of clinical cases. An electronic intensifier was found particularly useful.

RÉSUMÉ

Les possibilités de diagnostic et d'étude par le radiocinéma appliqué à la myélographie du canal rachidien sont démontrées dans un certain nombre de cas cliniques. L'intensificateur électronique s'est révélé particulièrement utile.

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KLINISCHE UND DIAGNOSTISCHE BEDEUTUNG CYSTISCHER WURZELTASCHEN ERWEITERUNGEN

von

REINHARD SCHOBER

Im Raum zwischen Ruckenmark und knochernem Wirbelsaulenkanal gelangen gelegentlich cystische Gebilde zur Entwicklung, die entweder im Inneren des Ruckenmarksackes oder ausserhalb im Cavum extradurale gelegen sind Sie konnen mit dem spinalen Subarachnoidalraum kommunizieren oder nicht Am haufigsten findet man sie aber im Bereich der Öffnungen des Wirbelsaulenkanales, also in den Foramina intervertebralia sowie im Hiatus sacralis, wo sie in naher Beziehung zu den Spinalwurzeln und ihren Taschen stehen

Die folgende Abbildung soll die anatomischen Verhaltnisse dieses Raumes veranschaulichen (Abb 1) Auf der rechten Seite ist die normale Situation wiedergegeben Die pia umkleideten ventralen und dorsalen Wurzeln durchbohren getrennt die Dura, eine zwickelartige Aussparung zwischen sich lassend werden sodann als Wurzelnerv von Arachnoidea und Dura eng umscheidet, das ist die Wurzeltasche und erreichen schliesslich den Abschnitt der durch das Ganglion der dorsalen Wurzel charakterisiert ist Hier gehen Arachnoidea und Dura fliessend ineinander uber und nehmen den Charakter eines Peri und Epineuriums an In der Umgebung der Wurzeltaschen hat die Arachnoidea Pacchioni sche Granulationen entwickelt, die der Liquorresorption dienen und in deren Umgebung sich die weiten Venenplexus des extraduralen Raumes befinden

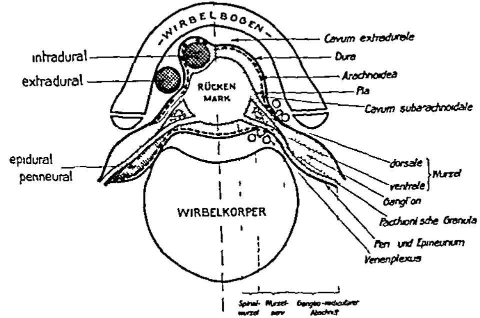


Abb 1 Anatomische Verhaltnisse schematisch gezeigt Auf der linken Seite ist skizziert an welchen Stellen sich cystische Bildungen entwickeln konnen Auf der rechten Seite ist di normale Situation wiedergegeben

Auf der linken Seite der Abbildung (1) ist schematisch skizziert, an welchen Stellen sich cystische Bildungen entwickeln konnen Das ist einmal der intradurale Raum die hier gefundenen Cysten haben haufig eine entzundliche Ursache im Sinne der sog Arachnitis cystica Es kann sich aber auch um Fehlbildungen also abgekammerte Meningocelen handeln Da ist ferner der extradurale Raum auch bei den hier anzutreffenden Gebilden handelt es sich in erster Linie um Entwicklungsstorungen der Ruckenmarkshaute also ebenfalls um Meningocelen Und schliesslich findet man cystische Gebilde in der Umgebung der austretenden Wurzel in der Nahe des Ganglions die als epidural perineurale Wurzeltaschen Erweiterungen bekannt sind

Nur von diesen zuletzt genannten Veranderungen soll hier die Rede sein weil sie am haufigsten sind und weil sie den beurteilenden Radiologen immer wieder vor die Frage stellen ob es sich hierbei um einen Zufallsbefund oder um Veranderungen mit echtem Krankheitswert handelt

Ich habe an einem Material von 247 Myelographien der verschiedenen Etagen in 20 Fallen derartige cystische Gebilde beobachten konnen deren Ausdehnung sich zwischen Pfefferkorn und Erdnussgrosse bewegte und die in 16 Fallen in der Lumbosacralregion und in 4 Fallen auch im Halsbereich lokalisiert waren wahrend der Brustabschnitt niemals befallen war

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Abb 4 49 jähriger Mann Knopfartige Erweiterungen mehrerer sakraler Wurzeltaschen

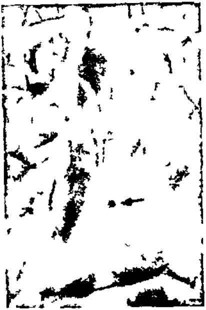


Abb 5 45 jahriger Mann Ausspannung der Wurzeltasche von S1 uber einem lumbosakralen Diskusbruch mit cystischer Erweiterung des distalen Wurzeltaschenendes

Bei dem 45-jahrigen Mann von dem die Abb 5 stammt konnte ebenfalls eine lumbosacrale Diskushernie entfernt werden Man beobachtet eine Verbreiterung und Auftreibung der linken S1 Wurzeltasche die wie bei der Operation zu sehen war sich uber den Bruch ausspannte und unterhalb davon eine cystische Auftreibung erkennen liess

Das cervicale Myelogramm eines 26-jahrigen Mannes ist in Abb 6 gezeigt bei dem seit einigen Wochen ein Schwachegefuhl im rechten Arm und in der rechten Hand aufgetreten war Man dachte an eine cervicale Diskushernie oder wollte sie zumindestens ausschliessen Das Myelogramm zeigte aber lediglich knopfartig ausgeweitete Wurzeltaschen C5 und C6 auf beiden Seiten Das Fall klarte sich dadurch dass einige Wochen spater an der rechten Hand neben dem Os pisiforme ein Ganglion entfernt wurde worauf die Ausfalle sofort verschwanden

Ein letztes Bild schliesslich (Abb 7) das ich nur zum Vergleich vorstellen mochte zeigt erheblich ausgeweitete verlangerte und deformierte Wurzeltaschen an C6 und C7 deren Ursache aber klar erwiesen ist Es handelt sich namlich um einen Zustand nach Ausriss dieser Wurzeln mit Zerreissung ihrer Taschen bei typischen Unfallmechanismus

In allen beobachteten Fallen, von denen ich nur einige Beispiele zeigen konnte bestand also keine Übereinstimmung zwischen der neurologisch klinischen Symptomatologie und dem myelographischen Befund an den Wurzel



Abb. 6. [illegible]6-jähriger Mann. Knopfartig ausgeweitete Wurzeltaschen an C5 und C6 auf beiden Seiten



Abb. 7. 24jähriger Mann. Cystische Erweiterungen der Wurzeltaschen C6 und C7 als Folgezustand einer massiven Zerreissung

taschen. Teils musste ein ausgedehnterer spinaler oder zentraler Prozess als Ursache des bestehenden Krankheitsbildes angenommen werden. Teils war die Läsion in der Peripherie zu suchen, und schliesslich bestand unter den 16 Beobachtungen lumbosacraler Wurzeltaschen-Erweiterungen 11 mal gleichzeitig eine Diskushernie, die ihrerseits eine ausreichende Erklärung für die Symptome gab.

Immerhin existieren in der Literatur eine ganze Anzahl von Fällen, bei denen die Entfernung solcher Gebilde Heilung oder Besserung brachte. Insgesamt sind aber die einzelnen Untersucher, was die klinische Bedeutung dieser Veränderungen anbelangt, geteilter Auffassung. Sie wird wohl im Wesentlichen davon abhängig sein, ob der Raumbedarf der Cyste so gross wird, dass eine Kompression von Wurzeln oder sogar die Konsumption des benachbarten Knochens eintritt. Und schliesslich dürfte hierfür auch das eventuelle Dazutreten einer entzündlichen Komponente ausschlaggebend sein. Damit komme ich auf die Ätiologie zu sprechen. Man hat diese Erweiterungen als Folgezustand einer Arachnitis zu deuten versucht, aber auch von anderer Seite als das Ergebnis und den Restzustand einer Wurzel- oder Ganglionapoplexie. Tatsächlich hat sich bei der histologischen Untersuchung eine chronische granulierende Entzündung in der Umgebung der Wurzeltaschen mit Hämosiderinablagerungen feststellen lassen.

Die von anderen Untersuchern und auch von mir beobachtete Häufigkeit dieser Wurzeltaschen-Erweiterungen von immerhin 5 bis 10 % erweckt aber gewisse Zweifel daran, dass durchwegs traumatische Blutungen (Apoplexien

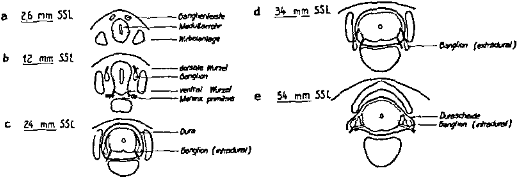


Abb 8 Entwicklung der Ruckenmarkshullen (schematisch)

oder Arachnitiden als Ursache zu gelten haben Es liegt meines Erachtens viel naher, diese entzundlichen Veranderungen als sekundar aufzufassen und primar eine variantenmassige Fehlbildung an den Wurzeltaschen und scheiden anzunehmen die bei dem hier vorhandenen dichten nebeneinander *ektodermaler und mesodermaler Keimblattanteile und bei der Kompliziert* heit des Entwicklungsmechanismus dieser Region auch in ihrer hohen Fre quenz eigentlich nicht verwundert

Die entwicklungsmassigen Besonderheiten der Ruckenmarkshullen und ihres Inhaltes sind in Abb 8 schematisch skizziert Beim 2 6 mm Foet erscheint zwischen Medullarrohr und Epidermis eine bilaterale Anhaufung von Zellen die Neural oder Ganglienleiste Unter zunehmendem Wachstum bewegen sich diese Zellverbande ventralwarts und liegen beim 12 mm Foet bereits seitlich des Medullarrohres, wahrend gleichzeitig von der Gang lienleiste die dorsale Wurzel aussprosst und vom vorderen Abschnitt der Medulla die ventralen Wurzeln nach vorne ziehen Dorsal von der Wirbel korperanlage beobachtet man bereits jetzt ein lockeres Gewebe die sog Meninx primitiva die sich spater zur Dura verdichtet und schliesslich unter Bildung des Cavum leptomeningicum lamellar aufgeblattert wird Die Gang lienleiste liegt also zu diesem Zeitpunkt noch intradural Spater beginnen die Ganglien entlang den Spinalnerven durch Locher in der Dura ventralwarts gegen die Foramina intervertebralia zu wandern und befinden sich schliesslich extradural Nun entwickeln sich aus den Durascheiden der Wurzeln Zellaus sprossungen die die Ganglien umkleiden und wieder in den intraduralen Raum einbeziehen Damit ist die spatere Wurzeltasche entstanden

Die Wachstumsgeschwindigkeiten von Wirbelsaule Ruckenmark und Ruckenmarkssack sind insofern verschieden als dass das Myelom und seine Hullen von einem bestimmten Zeitpunkt ab in der Langenentwicklung zuruckbleiben Diese Differenz in der Wachstumsleistung macht sich am caudalen Ende besonders bemerkbar Ist die Koordination des Langenwachs



Abb 6 26-jähriger Mann Knopfartig ausgeweitete Wurzeltaschen an C5 und C6 auf beiden Seiten



Abb 7 24 jähriger Mann Cystische Erweiterungen der Wurzeltaschen C6 und C7 als Folgezustand einer massiven Zerreissung

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Die von anderen Untersuchern und auch von mir beobachtete Haufigkeit dieser Wurzeltaschen Erweiterungen von immerhin 5 bis 10 % erweckt aber gewisse Zweifel daran dass durchwegs traumatische Blutungen Apoplexien

RÉSUMÉ

La myelographie a montré des dilatations kystiques des sacs radiculaires rachidiens dans les régions cervicale et lombaire dans 20 cas L auteur n accorde aucune signification pathologique à ce fait Ces kystes sont dus à des anomalies de développement de la moelle et de ses enveloppes et sont agrandis par les conditions de pression anormales telles qu il peut en survenir dans les hernies discales

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FROM THE SURGICAL AND NEUROSURGICAL SERVICES, VETERANS ADMINISTRATION HOSPITAL, BRONX 68, NEW YORK, U.S.A.

INTRAOSSEOUS EPIDURAL VENOGRAPHY IN THE DIAGNOSIS OF SURGICAL DISEASES OF THE LUMBAR SPINE

by

ROBERT A. SCHOBINGER and ERICH G. KRUEGER

Although the diagnostic value of Pantopaque myelography is undeniable certain limitations and undesirable side effects of the method have been reported. Clinical as well as experimental observations indicated adverse reactions to Pantopaque, involving the leptomeninges and neural structures, with subsequent meningitis, radiculitis, cyst formation and adhesive arachnoiditis (2, 3, 4, 6, 9, 13, 14, 19, 21, 22).

As a result Pantopaque myelography has been used mainly as a preoperative method in the precise localization of a clinically suspected intraspinal lesion. Many medical and surgical neurologists as well as orthopedic surgeons are reluctant to use it as a screening method in doubtful cases and particularly in individuals with emotional, neurotic or psychotic disturbances.

The mentioned adverse reactions to Pantopaque myelography dependent on the introduction of a potentially irritating substance into the subarachnoid space are not encountered with vertebral venography. The injection of a radiopaque medium into a spinous process permits a short lasting outlining of the internal venous plexus and intervertebral veins without leaving a trace

of the contrast medium, and furthermore without a resulting persistent cha... in the subarachnoid pressure This will avoid the aggravation of symptoms in the presence of an intraspinal mass occasionally observed after lumbar punct... and/or myelography Vertebral venography can, therefore, be used repea... as a screening procedure and in other instances where one would be hesit... to employ myelography

Aside from the mentioned adverse effects, Pantopaque myelography ca... a certain degree of diagnostic inaccuracy and technical failures (10 11, 20 25... Diagnostic errors occur particularly frequently in disc protrusions at the L5—S1 interspace, in about 20 per cent of the cases, due to a normal van... in the length and width of the dural cul de sac

In contrast to the extensive experience in the use of myelography verteb... venography has in recent years found only limited application in the diag... of metastatic tumors of the spine and in lumbar disc protrusions (5, 7, 8, 12 1... 18) An evaluation of its diagnostic potentiality in comparison with Pantop... myelography was therefore, undertaken in a group of 138 patients at the ti... of writing

In evaluating our results, we have found vertebral venography of value in a variety of lesions involving the lumbar spine and in a few instances the low... thoracic spine and their adjacent structures In the comparison of Pantopa... myelography and vertebral venography, it became, however, apparent th... both diagnostic methods have certain limitations and different potential... In certain circumstances, myelography appeared to be preferable and vi... versa Occasionally, venography assumed the role of a supplementary stud... adding valuable data

Anatomical considerations

The veins of the vertebral column form an intricate network which extend... along the entire length of the spine within the spinal canal and on the o... surface of the vertebrae

The *external vertebral venous plexus* consists of a posterior division which is located on the dorsal surface of the vertebral column between the sp... ous a... transverse processes, with cross communications between and above th... spinous processes It is also linked with its anterior counterpart which surro... the vertebral bodies The external vertebral venous plexus maintains com... nications to the internal plexus through the basivertebral veins intervertebral veins and branches which perforate the ligamenta flava The external verteb... venous plexus can thus exercise the function of a collateral circulatory path... in the presence of obstruction of the internal vertebral venous plexus In the cervical area the posterior division of the external venous plexus is particul... well developed forming here a deep and a superficial layer a peculiarity ... has also been venographically demonstrated (15 17)

The *internal vertebral venous plexus* which occupies the epidural space forms two pairs of longitudinal channels ventrally and dorsally extending along the entire length of the spine Their connection with the intracranial dural sinuses has been confirmed by BATSON (1) At each vertebral level the longitudinal veins are connected by a ring system of transverse veins

The *intervertebral veins* accompany the sleeves of the nerve roots and receive radicular branches from the spinal cord and cauda equina Together with the aforementioned basivertebral veins and branches which perforate the ligamenta flava, the intervertebral veins constitute the main part of a rich network of intercommunications between the internal and external venous plexus The latter in turn is linked with the segmental body veins, i e the lateral sacral lumbar posterior intercostal, and vertebral veins This arrangement of the vertebral venous systems allows collateral shunting in either direction between the inferior and superior caval circulation and the vertebral venous plexuses Alterations of the normal appearance of the internal vertebral plexus and intervertebral veins form the main basis for the phlebographic diagnosis of pathologic conditions involving the spinal column

Technique

The patient is sedated with demoral (100 mg) and seconal (100 mg) one hour prior to the procedure which is performed on a fasting patient and under 2 per cent procaine local anesthesia

The patient may assume several positions for satisfactory phlebography of the lumbar epidural plexus which will vary according to the disorder actually existing or suspected to exist

A Patients with congenital malformations of the spine intervertebral disc protrusions old vertebral fractures adhesive arachnoiditis vascular anomalies or perivertebral disorders are examined in the horizontal or jack knife prone position with concomitant effective inferior caval compression If the flat prone position is employed an inflatable balloon is placed between the patient s epigastrium and the top of a conventional roentgen table Large size films (35 5 × 43 cm) contained in a movable Bucky diaphragm are used Effective caval compression is achieved by holding the patient s back down with a constriction band such as is used in urography The mere purpose of the band is to prevent the patient from being lifted up by the inflated balloon The band is usually applied after adequate placement of the needle into the proper spinous process and the balloon is inflated immediately prior to the injection of the contrast medium Adequate caval compression is characterized by definite abdominal discomfort and frequently by reflux of marrow blood through the needle into the plastic connnecting tubing

The prone jack knife position may be better tolerated by patients with acute back pain Instead of placing the patient flat on a conventional roentgen

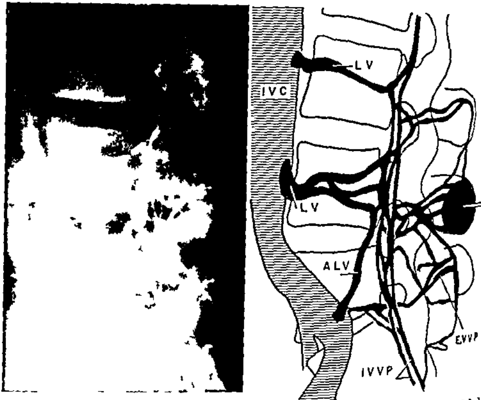


Fig 1 Normal lateral epidural venogram without caval compression IVC — inferior vena cava EVVP — posterior external vertebral venous plexus IVVP — internal vertebral venous plexus ALV — ascending lumbar vein LV — lumbar veins

table, a wedge shaped cassette holder (17 to 20°), admitting a 25 4 × 30 4 cm film in a stationary grid cassette is placed under the patient so as to clear the pubis The pubic area is adequately padded with foam rubber and the compression balloon placed between the top of the cassette holder and the patient s upper abdomen A constricting band is used in a fashion similar to that mentioned earlier The roentgen tube must be tilted to the proper angle in order to parallel the inclination of the wedge cassette holder

B Patients with vertebral metastases or inflammatory processes involving the spine including tuberculosis as well as those with recent vertebral fractures or aortic aneurysms are examined in a straight lateral projection without caval compression A Valsalva exercise may be executed by the patient In the first two mentioned conditions caval compression is omitted in order to minimize the danger of disseminating tumorous or infectious material through the vertebral plexuses which act as important collateral channels bridging caval obstructions

In these instances we like to carry out the roentgenographic exposure while the patient is holding his breath and executes a mild Valsalva exercise A

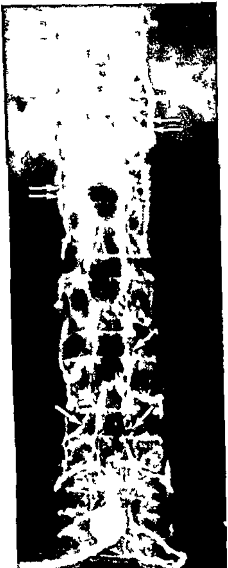
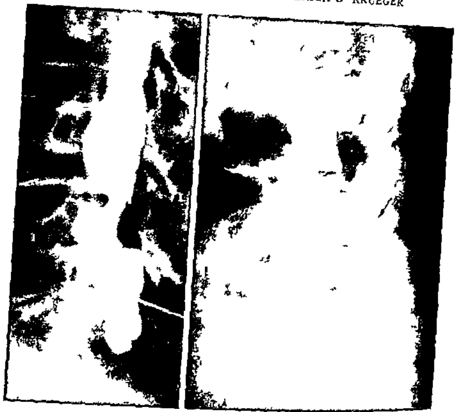


Fig ? Normal postero anterio epidural venogram with concomitant nferior aval comp ession Single arrows point to inte ert b al eins double arrow s to ascending lumba ve ns

strong Valsalva usually results in motion and loss of important angiographic details If the examination is carried out for tuberculosis of the spine it is perhaps best to execute two injections The first film is exposed with the patient taking shallow breaths through the open mouth and avoiding any straining in order to outline also the inferior vena cava (psoas abscess) The second angiogram is ob tained by a second injection but under a moderate Valsalva thus increasing the flow of blood over the vertebral plexuses and yielding more data on the hemodynam ics in these venous channels

C Oblique views with caval com press on may be required to roentgeno graphically rotate the ascending lumbar veins away from the epidural veins which the former channels may occasionally overlap on straight lateral views Oblique projections are sometimes also indicated to more clearly define certain angiographic details or to more precisely localize the site of maximal involvement of the epidural venous plexuses Caval compression is in these instances easily accomplished by placing a balsa wood ball between the top of a conventional roentgen table and the patient s umbilical region and asking the patient to rest his abdomen firmly against it without pushing The balsa wood ball is held in place on the table by sand bags or adhesive tape

Most of our examinations have been performed in the postero anterior or lat eral projections The forthcoming com parative conclusions drawn from this well controlled series of 138 cases are based on phlebograms obtained under standard technical conditions Since the various steps of the method have been discussed in detail elsewhere (16 18) they will be presented only in a summarized fashion

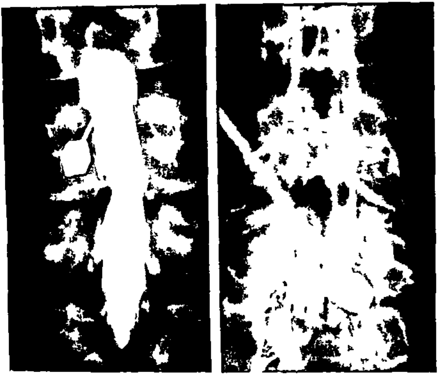


a b

Fig 3 a) Pantopaque myelogram Large protruded intervertebral disc L3—4 with extension toward body of L4 b) Intraosseous venogram Total block of epidural veins at midportion L4 corresponding to lower edge of protruded disc

Cannulation of a spinous process A spinous process, located preferably one or occasionally two, vertebral spaces below the level of suspected or roentgenographically evident pathologic conditions is identified Lead markers are placed over the selected process as well as over the one above and below A slightly overexposed preliminary film is taken with the shortest possible expos e time in order to verify the correct selection of the spinous process and the proper positioning of the patient as well as the various roentgenographic factors

Under strict asepsis 1 to 2 ml of 2 per cent procaine are injected into the skin, subcutaneous tissues and periosteum A 16 gauge Rosenthal bone marrow needle [illegible] turator in plac [illegible] introduced by a rotary motion of the hand into the [illegible] s process Can [illegible] ation of a spinous process can be easily done by han [illegible] experience t[illegible] of drills, hammers or surgical exposure was [illegible] to secure sat [illegible] y venograms [illegible] any [illegible] a control aspiration is performed which free flow of [illegible] blood This precaution is a must and will



a b

Fig. 4. a) Pantopaque myelogram revealing protruded intervertebral disc L4—5 right. b) Intraosseous venogram. Injection performed into spinous process of L5. Filling defect at L4—5 interspace right (side of tubing) with absence of intervertebral vein. (Compare with the normal left side.)

indicate the proper intraosseous placement of the needle. When this rule is followed, no faulty injections should occur.

After 2 to 3 ml of 2 per cent procaine have been introduced into the marrow space, 25 ml of Hypaque 50 % are rapidly injected with a 30 ml manual syringe (in 7 seconds or less). A roentgenogram is exposed during the injection of the last 3 to 5 ml of the contrast medium. Mechanical injectors are not employed, they are not necessary and may be dangerous.

After the injection the caval compression is released and the film immediately developed. If the desired informations have been obtained the needle is withdrawn and a dry sterile dressing applied. No special after care is necessary. Should additional views be desired, it is a simple matter to place the patient in the proper position leaving the obturated needle in place. The intraosseous injection is frequently associated with a strong sensation of local pressure which subsides very rapidly after termination of the injection of the contrast medium. Frank pain, particularly if lasting for 10 to 15 minutes, denotes extravasation



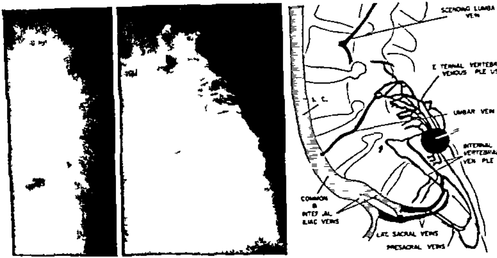
Fig 5 Intraosseous venogram Thinning and fanning out of epidural venous plexus in left L5—S1 interspace due to underlying disc (arrow) Epidural veins on right side in same interspace somewhat compressed medially

which may occasionally occur but which in our experience has been inconsequential

If the needle has been withdrawn it should not immediately be re introduced into the same spinous process since contrast medium will reflux through the previous puncture hole A different spinous process should be selected in these instances or the procedure repeated after a day or two

Intraosseous venography is obviously contraindicated if the skin or soft tissues are injected or otherwise diseased rendering osseous puncture unsafe

Cannulation of a spinous process may be impossible after surgical intervention in the area (spine fusions for example) or if the bony prominence is so narrow as not to admit the needle Bilateral simultaneous injections into the lateral sacral bone, or rarely into the posterior iliac spine may then be resorted to In the case of a narrow sacral spinous process it is not infrequently possible to outline the L5—S1 interspace in a retrograde fashion by introducing the needle into a lower lumbar spinous process



a b c

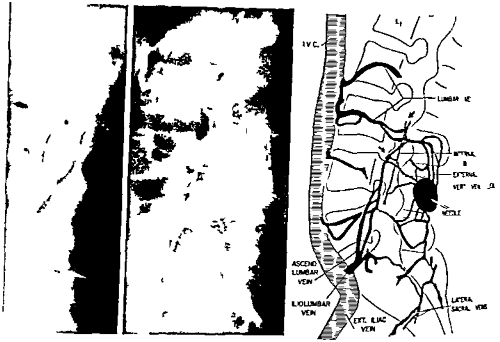
Fig 6 Spondylolisthesis a) Myelogram revealing almost total block at L5—S1 junction b) Intraosseous venogram Epidural veins completely blocked at level of L5—S1 with considerable lateral and retrograde flow of medium (compare schematic drawing)

Results

Normal spine The contrast medium promptly outlines the external and internal vertebral venous plexuses Without caval compression or Valsalva exercise it will extend in cephalad and caudad direction and only over a few vertebral spaces (Fig 1) If however the caval circulation is retarded or interrupted the flow within the internal vertebral venous plexus is definitely more marked in cephalad direction thus resulting in excellent contrast filling of these channels over the entire lumbar and lowermost dorsal spine if for example the contrast medium has been injected into the spinous process of L5 or S1

In the postero anterior projection the system of epidural veins appears as a continuous ladder of well outlined channels (Fig 2) The horizontal venous rings are situated at the level of each lamina and connect the longitudinal sinuses The intervertebral veins are also filled over many interspaces and after a slightly oblique downward course corresponding to the direction of the nerve root enter the ascending lumbar veins which are located along the lateral aspects of the vertebrae

Intervertebral disc protrusions Phlebography is a sensitive indicator of pressure changes affecting the epidural venous system in view of the close proximity of



a b c

Fig 7 Ependymoma of cauda equina a) Myelogram revealing typical appearance of intraspinal neoplasm b) Intraosseous venogram c) Areas of posterior displacement and squeezing of epidural plexus corresponding to extent of tumor (arrows)

this plexus to the bony walls of the spinal canal Hence disc protrusions can easily be detected The examination is particularly valuable at the L5-S1 interspace where Pantopaque myelography tends to be less accurate than at other lumbar levels Indeed epidural venography was found to be of equal accuracy as this method of myelography in the diagnosis of protruded discs of the lumbar spine but venography was superior at the L5 S1 interspace

Protruded intervertebral discs tend to produce a localized filling defect of variable extent This defect involves the epidural veins and corresponding intervertebral veins The normal venographic pattern is rather promptly resumed cephalad to the lesion, usually already in the space above Hence it is also possible by phlebography to detect disc protrusions at two interspaces Depending upon the degree of epidural block a certain degree of stasis distal to the lesions and evidence of retrograde and collateral blood flow is observed. While large disc protrusions may result in a total either unilateral or bilateral epidural venous block (Fig 3), smaller disc protrusions may be characterized by a mere thinning (Fig 4), fanning out (Fig 5) or lateral displacement of the local epidural plexus The intervertebral vein corresponding to the level of the lesion may be, roentgenographically speaking, completely absent or show an elevation or partial lack of filling in its medial portion

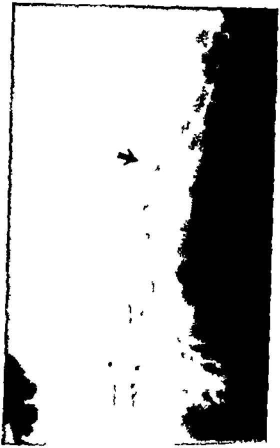


Fig 8 Osteolytic vertebral metastasis Total block of internal vertebral venous plexus (arrow) The venous channel continuing cephalad is the ascending lumbar vein as was demonstrated in the oblique views Hence there was no extravertebral extension of the tumor

Conclusions

Intraosseous epidural venography is a technically convenient and expedient method to evaluate the lumbosacral spine in the aforementioned disorders After some experience with this standardized technique, not more than 30 minutes should be required for the procedure

Epidural venography should be used as the initial diagnostic procedure with myelography reserved for those instances where venography fails to corroborate the clinical signs Since venography does not result in the introduction of irritating substances into the subarachnoid space it can be considered the method of choice whenever myelography appears to be contraindicated whatever the reason may be

Most of our patients are now operated upon, based on clinical and venographic findings alone, and this with consistently satisfactory results

While more experience with transspinous epidural venography must be gathered in certain types of the aforementioned lesions it can, however be stated that the method is equal in accuracy to Pantopaque myelography in the diagnosis of intervertebral disc protrusions and congenital anomalies It is superior to myelography in the diagnosis of protruded discs at the L5 S1 interspace and of vertebral metastases

Extension of the applications of epidural venography to lesions of the thoracic spine has demonstrated that the method offers a high degree of diagnostic accuracy also in that area This may prove to be of some clinical significance since the lack of cohesion of the Pantopaque contrast column in the thoracic area not infrequently results in diagnostic difficulties

The added advantage of venography to detect paravertebral lesions prevertebral abscesses retrocaval neoplasia and even visceral metastases with one properly executed examination is hardly duplicated by Pantopaque myelography

SUMMARY

A comparative study of intraosseous venography and pantopaque myelography in the diagnosis of surgical diseases of the lumbar spine is presented and the anatomy of the vertebral venous system and the venographic technique employed are described The results obtained in a group of 138 patients with various lesions such as disc protrusions congenital abnormalities adhesive arachnoiditis radiation myelitis primary and metastatic neoplasms are discussed The conclusions is reached that venography can replace Pantopaque myelography in most instances and should be used as the initial diagnostic procedure

ZUSAMMENFASSUNG

Es wird eine vergleichende Studie von intraossarer Venographie und Pantopaque Myelographie bei der Diagnosestellung von chirurgischen Erkrankungen der Lendenwirbelsaule angestellt und die Anatomie des vertebralen Venensystems und die Technik der Venographie wird beschrieben Die Resultate die 138 Patienten mit verschiedenen Erkrankungen wie z B Diskusprotrusion cong Anomalien adhasive Arachnoiditis Bestrahlungsmyelitis prim und metastatische Neoplasmen umfassen werden besprochen Es wird der Schluss gezogen dass die Venographie in den meisten Fallen die Pantopaque Myelographie ersetzen kann und als einleitende diagnostische Untersuchung angewendet werden soll

RÉSUMÉ

Les auteurs font une étude comparative entre la phlébographie intra-osseuse épidurale et la myelographie au Pantopaque pour le diagnostic des affections chirurgicales de la colonne lombaire ils décrivent l anatomie du systeme veineux vertébral et leur technique phlébographique Ils étudient les résultats obtenus sur 138 malades atteints de diverses lésions telles que hernies discales malformations congénitales arachnoidite adhésive myélite post radiothérapique néoplasies primitives et metastatiques Ils arrivent à la conclusion que la phlebographie peut remplacer la myelographie au Pantopaque dans la plupart des cas et qu elle devrait etre utilisée comme premier examen diagnostique

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AUS DER RÖNTGENABTEILUNG (LEITER H. J. SIELAFF) DER MEDIZ. UNIV.-KLINIK
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NEUROVEGETATIVE ORGANIRRITATIONEN DURCH SPONDYLOPATHIEN

von

HANS-JÜRGEN SIELAFF

In der Wirbelsäulenforschung wurden aufschlußreiche Zusammenhänge zwischen Spondylopathien und neruovegetativen Organirritationen aufgedeckt. Wir erinnern an die Migraine cervicale, vasomotorische Störungen beim Schulter-Hand-Syndrom und die vasomotorische Angina pectoris bei cervikaler Osteochondrose.

Wir haben in den letzten Jahren festgestellt, daß Erkrankungen der Hals- und Brustwirbelsäule auch zu Tonus- und Motilitätsstörungen des Intestinaltraktes eindeutige Beziehungen haben. So wiesen wir bei 135 Patienten mit cervikaler Osteochondrose in etwa 2/3 der Fälle pathologische Schluckakte und deutliche Tonusstörungen des Oesophagus nach. Für die Funktionsdiagnostik des Halswirbelsäule und des Intestinaltraktes verwenden wir die 5 Zoll Bildverstärker- und 9 Zoll Bildverstärker-Televisions-Kinematographie. Seit kurzem erlaubt uns die direkte Televisions-Schirmbild-Kinematographie bei durchaus gleichwertigen Ergebnissen gegenüber der konventionellen Bildverstärker-Kinematographie eine wesentliche Reduktion der Einfallsdosis, die sich den üblichen Durchleuchtungsbedingungen weitgehend anpaßt. Das Bewegungsbild der normalen Halswirbelsäule ist harmonisch und basiert auf der erhaltenen Modellierbarkeit der Bandscheiben. Leichte Ventralverschiebungen der Wirbelkörper scheinen noch in den Bereich des Physiologischen zu gehören.



Abb 1 (oben) Kinematographische Funktionsdiagnostik der cervikalen Osteochondrose Fixation von C5/6 Hypermobilisation von C4 (zwei Einzelbilder aus 35 mm Film in Beugung und Streckung)

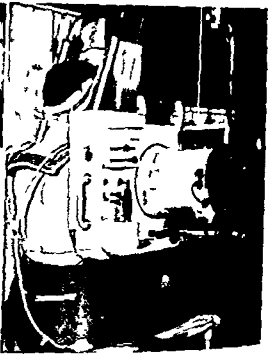


Abb 2 (rechts) Extension der Halswirbelsaule wahrend Bildverstarker Kinematographie des Oesophagus

Dorsalverschiebungen durften jedoch sicher pathologisch sein Über d Grenzen des Normalen und Anfange des Pathologischen mussen noch we Untersuchungen angestellt werden

Bei den Anfangsstadien der cervikalen Osteochondrose, die bereits im jugendlichen Alter zu beobachten sind, findet sich meist Geradhaltung de Halswirbelsaule ohne nennenswerte Bandscheibenerniedrigungen oder Reaktionen Man erkennt jedoch schon fixierte Wirbelsegmente und kr davon Segmente erhohter Beweglichkeit mit beginnender Dorsalverschie Die fortgeschrittene cervikale Osteochondrose wird durch zunehm Fixation und Lockerung verschiedener Bewegungssegmente charakter Auch hier herrscht Fixation in den kaudalen, Lockerung in den kra Segmenten vor In den Endstadien des Krankheitsbildes resultiert eine verselle Versteifung der Halswirbelsaule welche kaum noch eine Bewe funktion zuläßt

Wahrend der normal tonisierte Oesophagus sich nach dem Schluck sofort ergiebig kontrahiert, findet sich bei der fortgeschrittenen Osteocho vorwiegend die hypotone Funktionsstorung mit ungenugender und verz einsetzender Kontraktilitat Wir sind der Auffassung daß die Haufig hypotonen Funktionsstorung auf ursachliche Zusammenhange zwi ostrochondrotischen Fehlstellungen der kleinen Wirbelgelenke u d Re zungen sympathischer Nervenelemente im Bereich der Gelenkkapseln Foramina intervertebralia hinweist Durch Extension der Halswirbel

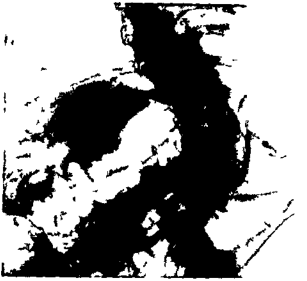


Abb 4 Abdomineller Meteorismus bei hochgradiger Kyphoskoliose der Brust und Lendenwirbelsaule



Abb 5 Abdomineller Meteorismus bei Metastasen der Brust und Lendenwirbelsaule

dylogene sympathische Irritationen handelt, die zu Tonusherabsetzung, Hypomotilitat und Gasbildung fuhren Bekanntlich finden sich erhebliche meteoristische Tonusstorungen bei zentralnervosen Prozessen wie Polioencephalitis, Hirntumor und anderen organischen Hirnkrankheiten An erster Stelle steht die extreme Kyphoskoliose der Brustwirbelsaule mit sekundaren Osteochondrosen, Spondylosen und Spondylarthrosen Des weiteren sind zu nennen Metastasen, Osteosarkom, multiples Myelom, Spondylitis tuberkulosa, Morbus Bechterew und posttraumatische Wirbelveranderungen Kontrastuntersuchungen des Magen Darmkanals bestatigen diese Tonusstorungen, Hypotonie uberwiegt, es finden sich jedoch auch hypertone Storungen oder wechselnde Tonusverhaltnisse von Magen und Dunndarm, wobei sympathische Ausfalle bzw parasympathische Reizzustande diskutiert werden mussen

Wir sind somit der Auffassung daß derartige Tonusstorungen und Meteorismen Zusammenhange zu Spondylopathien der Hals und Brustwirbelsaule erkennen lassen und Hinweise auf segmentare oder diffuse Wirbelerkrankungen geben konnen Bei der Beurteilung von Rontgenaufnahmen der Wirbelsaule sollte daher sorgfaltig auf derartige Befunde geachtet werden

ZUSAMMENFASSUNG

Spondylopathien der Hals und Brustwirbelsaule gehen haufig mit intestinalen hypotonen Funktionsstorungen einher Bei cervikaler Osteochondrose bewirkt Extension der Halswirbelsaule Normalisierung von Oesophagus Hypotonie Hieraus ist auf die spondylogene Ursache derartiger neuro-vegetativer Funktionsstorungen zu schließen Abdomineller Meteorismus kann auf segmentale oder diffuse Spondylopathien hinweisen

SUMMARY

Spondylosis of the cervical and thoracic spine is frequently associated with hypotonic disturbances of the alimentary tract. Extension of the cervical spine in cervical osteochondrosis frequently leads to a return of oesphageal hypotonia to normal. This fact seems to prove that there is a causative connection between neurovegetative disturbances and spondylosis. Abdominal meteorism may point to segmental or diffuse spondylosis.

RESUMÉ

Les affections vertébrales cervicales et dorsales s'accompagnent souvent de troubles fonctionnels hypotoniques intestinaux. Dans la discarthrose cervicale l'extension de la colonne cervicale fait disparaître l'hypotonie oesophagienne. On peut en conclure que ces troubles fonctionnels neuro-végétatifs ont une cause vertébrale. Le météorisme abdominal peut être un signe d'affection rachidienne segmentaire ou diffuse.

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SUMMARY

Twenty cases of intrasacral radicular cysts diagnosed by oily contrast myelography are described The morphology of such cysts varies and it is difficult to determine whether they are perineural or extradural. Twenty-five per cent of the cysts produced no symptoms and roentgenologic appearances were the same as in those that were detected clinically. It would appear that the localization of a cyst depends solely upon the clinical evidence of the root affected

ZUSAMMENFASSUNG

Zwanzig Falle von intrasakralen Wurzelcysten wurden mit Hilfe von olhaltigen Kontrastmittel myelographisch diagnostiziert. Die Morphologie dieser Cysten ist verschiedenartig und die Entscheidung ob sie perineural oder extradural sind, ist schwierig Funfundzwanzig Prozent der Cysten waren ohne Symptome und die Rontgenbefunde die gleichen wie bei denen mit klinischen Zeichen. Die klinischen Erscheinungen scheinen abhangig von dem Ort zu sein an dem die Cyste der Nervenwurzel ansitzt.

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SACRAL CYSTS

by

DAVID SUTTON

A number of cyst like conditions are described in the literature as arising in or from the sacrum These have been described under various names and include intra sacral meningocele 'intra sacral cyst, 'anterior sacral mening ocele, and sacral extra dural cyst In addition interest has been raised in recent years in the condition of 'sacral peri neural cysts as described by TARLOV (1953)

The purpose of this paper is first to review a number of these cases person ally encountered in the last ten years, and second to examine the thesis that some of these conditions may be of similar aetiology, and may merely represent different manifestations of the same basic pathologic process We will consider lesions under three subheadings

Anterior sacral meningocele

Clinically these may be asymptomatic or they may present with pressure on the rectum or the bladder The majority of reported cases have been in females and no satisfactory explanation of this sex incidence has been put forward Some of the cases are found as cystic swellings at a routine gynaecologic examination This was so in our own case and in others recorded in the litera ture This fact may help to explain the apparently high female sex incidence



a b

Fig 1 Lateral views of sacrum The intrasacral expanding lesion is seen more clearly in the tomogram (b)

Previous authors emphasize the dangers of surgery in this condition particularly if the true nature of the condition is not realised According to SHERMAN et coll (1950) meningitis supervened in 15 out of 26 recorded cases which underwent operation and this was fatal in 11 cases

Case report A woman of 34 was found to have a pelvic mass at a routine postnatal examination Operation revealed a so called retro-peritoneal cyst This was described as closely applied to the sacrum and ruptured during removal It was said to be non malignant and with a wall of fibrous tissue only

The cyst rapidly recurred necessitating a second operation three months later This time hysterectomy was done to allow total removal of the cyst which was found to be attached to the sacrum

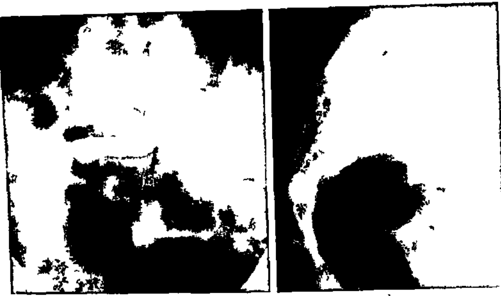
Postoperatively a pelvic abscess developed which had to be drained for 1? days Soon after severe back pain began followed over the next few months b an increasing spastic paraplegia She was finally transferred to our hospital in June 1952 with signs of cord compression at D8

At *conventional roentgen* examination an intrasacral expanding lesion was found which was better seen at tomography (Fig 1)

Myelography by the cisternal route using Myodil showed a block at D8 with encysted pockets of contrast medium suggesting arachnoiditis

Operation confirmed an adhesive arachnoiditis with pockets of cloudy cerebrospinal fluid. Rather surprisingly there was considerable improvement clinically after operation.

The roentgen findings in this case consisted of a smooth expansion of the sacral canal with erosion of the posterior aspects of the vertebral bodies and

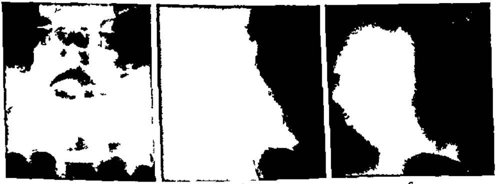


a b

Fig 2 Myodil outlining intrasacral cyst in a p (a) and lateral (b) views

is identical with the changes seen in our next group of cases — the intrasacral cysts or intrasacral meningoceles

At myelography positive contrast entered the sac in most cases of anterior sacral meningocele described in the literature This was not so in our case but it is clear that previous operation and infection with adhesive arachnoiditis had complicated the picture



a b c

Fig 3 A p view (a) lateral view (b) and tomogram (c) of intrasacral expanding lesion



a b

Fig 4 P a (a) and lateral (b) views showing Myodil to have entered the cyst and antero-lateral herniation of the cyst



Fig 5 Autopsy specimen from the same case as represented *in figs 3 and 4 Sagittal section of sacrum the cyst* communicates with the subarachnoid space and appears to be attached to a single nerve root



a b c

Fig 6 a) A p view of sacrum showing deformity and intrasacral expanding lesion b) P a myelogram and c) lateral view both showing Myodil in the cyst

Intrasacral cysts or intrasacral meningoceles

We have encountered a number of cases which may be classified in this group and have been fortunate in obtaining postmortem specimens of two cases

Case 1 A woman of 45 complained of severe low back pain The conventional roentgen films were considered to be normal but eventually a myelogram was performed A loculated intrasacral cyst which communicated freely with the spinal subarachnoid space (Fig 2) was found

The patient was treated conservatively

Case 2 A man of 44 was admitted to hospital with a history of recent headache and vomiting and also of severe low back pain which had been present 3 or 4 years Neuroradiological investigations revealed a tumour of the corpus callosum Biopsy proved this to be a glioma and the patient died in hospital soon after

Prior to this however his spine had been roentgen examined and an expanding lesion revealed which was suspected as a chordoma or deposit at another hospital (Fig 3) Clearly this was an intrasacral cyst

Myelography with a small amount of Myodil showed the cyst to communicate freely with the lumbar subarachnoid space (Fig 4) The autopsy specimen was obtained and dissection appeared to show only one nerve root entering the cyst a point which will be referred to later (Fig 5)

Case 3 The patient was a young medical man aged 27 who presented in 1958 with the following history Since the age of sixteen he had noticed a pes cavus and in 1950 he had a sub-cutaneous tenotomy of the outer two tendons of the left foot In 1957 he noticed urgency and developed frequency which had increased recently A few months before admission he developed nocturnal enuresis

In the conventional *roentgen* films of the lumbo-sacral spine an apparent dilatation of the spinal canal in all directions was observed The terminal segments of the sacrum appeared malformed small and displaced to the right (Fig 6a)



a b

Fig 7 Lateral conventional view of sacrum (a) and lateral tomogram (b)

Myelography confirmed the diagnosis of sacral cyst communicating with the subarachnoid space (Fig 6 b and c)

Operative intervention was thought to be undesirable in view of the possibility of rendering the sacral nerve involvement worse

Case 4 A man of 26 complained of low back pain on and off for seven years Over the past year the pain had become worse Its site varied sometimes on the right and there was no radiation down the leg The pain was not disabling and was noticed more when he was sitting or lying

On examination movements were full and there were no positive physical signs Conventional *roentgen* examination showed the typical appearances of a sacral cyst This was well shown by tomography (Fig 7)

No treatment was advised He was seen again six months later when he was almost free from symptoms and no change in the appearances of the cyst was found at roentgen examination

Case 5 This patient a man of 43 died in St Mary s hospital in 1944 from bacterial endocarditis Five years previously in 1938 his back was roentgen examined after a fall, and an erosive lesion of the sacrum was found This was unfortunately misdiagnosed as a chordoma and treated by radiotherapy in 1939

After his death in 1944 the autopsy specimen of the lumbar spine was obtained and this clearly revealed a sacral cyst communicating freely with the subarachnoid space (Fig 8a) The original roentgen films were no longer available but roentgen examination of the specimen showed similar features as our other cases (Fig 8b)

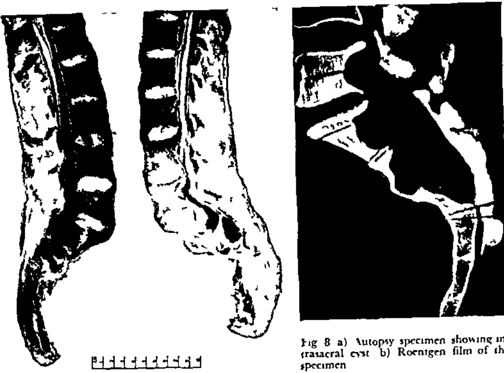
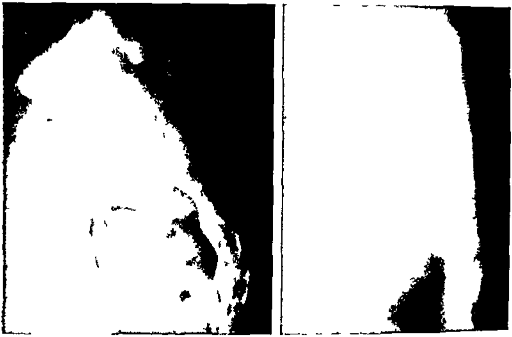


Fig 8 a) Autopsy specimen showing intrasacral cyst b) Roentgen film of the specimen

Perineural cysts

In 1938 TARLOV first described the presence of cysts of nerve roots within the sacral spinal canal which he termed perineural cysts This pathologic condition was demonstrated at autopsy and was not considered to be of clinical importance The etiology was obscure, though it was thought that the cysts might be degenerative In 1948 TARLOV described a patient with sciatic pain who was cured by removal of a sacral cyst similar to those he had previously described In 1953 he published a small monograph on the subject and reported the discovery of 8 cysts in 60 autopsies He considered that perineural cysts were relatively common, and could produce symptoms though many of them when small, were asymptomatic He reviewed ten cases of perineural cysts with clinical symptoms, including four personal cases and emphasized that these cysts could produce symptoms and signs which were at times disabling

As regards roentgenologic changes he stated that erosion of the posterior sacral arch may occur and was present in two of the ten collected cases with clinical symptoms Myelography with positive contrast medium was performed



a b

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It is well known that positive contrast media accidentally injected into the subdural space will rapidly track out along nerve roots possibly the medium is taken up in the perineural lymphatics However we have also noted that when subarachnoid positive contrast medium is left in the spine it may also track out along sacral nerve roots though usually in a much more delayed and limited manner Where this has occurred the contrast medium may collect in a sacral cyst if one be present

We have recently reviewed 200 Myodil myelograms, where the Myodil was left in situ, and not removed at the time of examination We found 16 cases with what appeared to be sacral cysts of varying sizes outlined by Myodil (Fig 9)

These findings confirm the opinion of TARLOV that perineural sacral cysts are not uncommon The similarity of the findings at myelography in patients with large cysts to those seen in patients with giant sacral cysts raises the possibility that the two conditions are related

SUMMARY

Giant sacral cysts with pathologic changes at conventional roentgen examination and at myelography are not uncommon and five cases are described A case of anterior sacral meningocele with similar changes is also described It seems possible that these giant sacral cysts are related to the perineural cysts of TARLOV These latter are quite common and we have found them in 16 out of 200 cases where positive contrast myelography was used and the contrast medium was left in situ

ZUSAMMENFASSUNG

Riesensakralcysten mit pathologischen Veranderungen am konventionellen Rontgenbild und Myelogramm sind nicht ungewohnlich Funf solche Falle sowie ein Fall von vorderer Sakrum Meningocele mit ahnlichen Veranderungen werden beschrieben Es besteht die Moglichkeit dass diese Riesensakralcysten mit den perineuralen Cysten von TARLOV verwandt sind Diese sind relativ haufig Wir haben sie in 16 von 200 Fallen gefunden wobei Myelographie mit positivem Kontrastmittel verwendet worden war

RÉSUMÉ

Les kystes sacrés géants donnant des signes pathologiques sur les radiographies simples et sur les myélographies ne sont pas exceptionnels l'auteur en présente cinq cas Il décrit aussi un cas de méningocele sacree antérieure donnant des signes analogues Il semble possible que ces kystes sacrés géants soient apparentés aux kystes périneuraux de TARLOV Ceux-ci sont assez communs et nous en avons trouvé dans 16 cas sur 200 ou on avait fait une myélographie avec un moyen de contraste positif laissé *in situ*

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MENINGO- AND MYELOMENINGOCELE STUDIED BY GAS MYELOGRAPHY

by

M SWEDBERG

The embryonic central nervous system arises from the ectodermal neural plate This deepens into a groove that fuses posteriorly, the closure starting in the cervical region and proceeding in a cranial and caudal direction The neural tube so formed contains the primitive ventricles and the central canal of the spinal cord which at this time is merely a continuation of the fourth ventricle

Malformations of the spinal cord and its meninges may, according to the araphic theory introduced by von RECKLINGHAUSEN (1886), be caused by defects in this closure mechanism and a dysraphic state may ensue The other main theory on the origin of myelomeningoceles and associated malformations was offered by MORGAGNI (1761) and has been further elaborated by GARDNER (1960) According to the latter a state of physiologic hydrocephalus and hydromyelia prevails in the 5th week of gestation The increasing pressure within the primitive ventricles and the central canal opens the foramina of Lushka and Magendie and, through these, a subarachnoid space is formed, the distension of the neural tube is thus relieved by absorption of spinal fluid If this process is delayed the intraluminal pressure will cause bulging or even rupture of the spinal cord, and if the increase of pressure of the cerebrospinal fluid does not take place until a subarachnoid space has been formed there may be a bulging of the meninges alone

Only conditions below the foramen magnum will be considered in this communication The simplest form of dysraphic malformation is spina bifida occulta, in which there is a defective midline closure of the vertebral arches but no pouch formation of the coverings of the medulla A protrusion of the meninges usually situated in the posterior midline, constitutes a meningocele If the spinal cord or part of it protrudes into such a sac or is attached to its base a myelomeningocele results The spinal cord is exposed in the most serious form of dysraphic malformation, a condition called a myelocele CAMERON (1956) pointed out that the majority of so-called myelomeningoceles are in reality myeloceles in which the opened and flattened posterior surface of the spinal cord has been covered by dermal epithelium that has grown in from the borders of the defect

FISHER UHLEIN & KEITH (1952) published a series of 530 cases of cranium bifidum and spina bifida of the 336 myelomeningoceles and 137 meningoceles of the vertebral canal, 383 were situated in the lumbar lumbosacral or sacral region The frequency of these kinds of malformations at the lower end of the spine probably depends on the fact that this is where the closure of the neural tube as well as the ossification of the vertebral arches is last completed

The meningocele is frequently detected at birth and operated upon within a short time Most of these cases are diagnosed by clinical methods such as inspection and palpation of the meningocele and the fontanelle simultaneously and puncture of the sac with aspiration of fluid or combined with pressure measurements under jugular compression or with dye injection elsewhere in the subarachnoid space

Myelography is however the most reliable method and was apparently first used by EICHLER (1927) with Lipiodol as the contrast medium, to diagnose a meningocele Gas myelography was first employed in this condition by LINDGREN (1938) The technique of gas myelography as performed by the present author has been described by LINDGREN ODEN RUGGIERO, and others It may suffice to point out that it is necessary to drain all the spinal fluid from the part of the subarachnoid space to be examined and replace it with gas The head is kept low during the examination in order to prevent gas from entering the cranial cavity and, inversely fluid from the intracranial liquor spaces from flowing into the spinal subarachnoid space Tomography at high kilovoltage makes it possible to eliminate the disturbing masking by skeletal and other structures (ODEN 1953 BONTE DELFOSSE & CECILLE 1960)

The author considers gas myelography to be superior to myelography with oily contrast media for several reasons The gas readily enters the meningeal sac which is not always the case with positive contrast media Lipiodol Pantopaque and Myodil, for example may take hours or even days to enter the sac if its neck is narrow (ARCHER COOPER & CIMMINO 1948 HADDAD 1958 POOL 1952, ROWLANDS 1955, SHIDDLER & RICHARDS 1943 ZACKS 1960) The positive contrast medium furthermore does not simultaneously fill the whole



a b c

Fig 1 Case 1 Myelomeningocele a) Lateral view of lower thoracic and lumbar spine The spinal cord is normal in the thoracic region arrows indicate the anterior surface of the medulla b) Lateral tomographic view of lumbar and sacral regions Absence of the conus medullaris the flattened caudal end of the spinal cord adheres to the posterior border of the vertebral canal and extends as far down as the opening into the meningeal herniation (arrows) c) Lateral view with horizontal beam direction The patient has been placed prone with the head down to obtain maximum filling of the myelomeningocele

of the meningocele, with neck, and adjoining parts of the subarachnoid space (24), at least not if reasonable amounts are employed Gas myelography produces a clear delineation of the whole spinal subarachnoid space and reveals the relation between the spinal cord and the meningeal herniation and thus makes it possible to distinguish between a meningocele and a myelomeningocele This is of the utmost prognostic importance and facilitates the planning of an eventual operation The following examples will demonstrate the diagnostic value of the method

Case reports

Case 1 (Fig 1) Boy aged 2 years with weakness of the lower limbs and incontinence of urine A soft mass about 10 cm (4 inches) in diameter was present in the sacral region

Conventional roentgenograms of the spine revealed spina bifida from the level of L4 downwards



a b

Fig 2 Case 2 Myelomeningocele a) Frontal view of lumbosacral region Large defects in the posterior arches of L4 L5 and the sacrum b) Lateral tomographic view The spinal cord is surrounded by gas as far down as L3 further down it is fixed to the posterior wall of the vertebral canal and enters the upper part of the myelomeningocele

Gas myelography The cervical and thoracic portions of the medulla were quite normal. A slight swelling of the cord continuous downward from L1 was evident The spinal cord was fixed to the posterior border of the vertebral canal down to the opening into the meningeal sac just below the incomplete posterior arch of L5 Maximum gas filling of the meningeal sac was produced by placing the patient prone and a lateral view with a horizontal beam was obtained (Fig 1c) The communication between the herniation and the subarachnoid space was unusually wide The actual nerve roots cannot be seen at gas myelography but experience has shown that when the spinal cord is fixed to the wall of the spinal canal close to the stalk of the meningocele nerve roots lie in its interior or imbedded in its wall

A myelomeningocele containing several nerve roots was found at operation Many neurosurgeons speak of a myelomeningocele if the herniation contains nerve roots a thorough microscopic examination of the wall of a myelomeningocele will practically always disclose tissues of central nervous origin

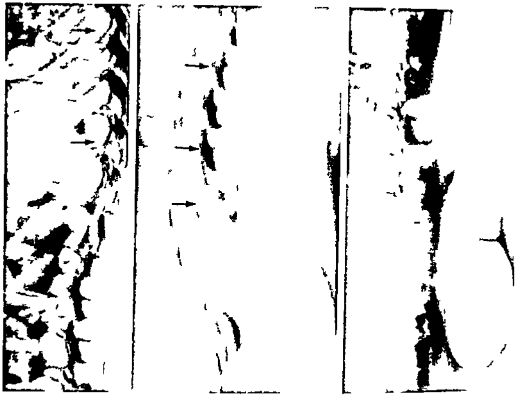


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a b

Fig 4 Case 4 Sacral myelomeningocele a) Lumbar region lateral The spinal cord does not end at the normal level but continues down through the whole length of the vertebral canal total absence of lumbar intumescence b) Lateral tomography of sacral region The sacral canal is abnormally wide and the subarachnoid space fills it completely (intrasacral herniation of the meninges) the spinal cord reaches as far down as the sacral hiatus where it is attached to a tumour like formation (arrows)

Case 3 (Fig 3) Boy aged 11 months was found to have a swelling the size of a hen s egg in the lower lumbar region No reflex changes muscular weakness or loss of sensibility

Conventional films of the spine revealed a widening of the vertebral canal in the lower lumbar and sacral regions with large defects in the sacrum (Fig 3a)

Gas myelography The subarachnoid space was found to communicate with a cavity measuring about 5 × 2 5 cm (2 × 1 inches) and situated behind the upper part of the sacrum into the upper part of which the lower end of the spinal cord entered (Fig 3 b and c)

A myelomeningocele with several nerve roots embedded in its walls was found at operation

Case 4 (Fig 4) Man aged 34 with disturbances of the anal and urinary sphincters slight paresis of the left leg hypoesthesia of the perianal area as well as attacks of girdle pain and muscular twitching in the left thigh A hairy soft sessile tumour was evident a few centimetres to the left of the anus

Gas myelography The subarachnoid space extended down to the sacral hiatus and was concentrically enlarged in the sacral canal The spinal cord instead of ending at the normal level extended practically unaltered in size through the whole of the subarachnoid space there was no medullary cone The cord was attached at the sacral hiatus to a rounded formation Gas myelography thus demonstrated an intrasacral herniation of the subarachnoid space and an abnormal fixation of the lower end of the spinal cord

Meningo- and myelomeningoceles in the lower lumbar and sacral regions are often combined with teratoma dermoids lipoma or cysts (1 34) and the caudal end of the spinal cord is often coalesced with neural elements fat tissue and cutaneous components

Operation in this case revealed that the spinal cord was attached to a conglomerate of nerve roots and connective tissue at the sacral hiatus

Case 5 (Fig 5) Girl aged 3 years who was born with a myelomeningocele that extended from Th10 to S2 and was operated upon 2 days after delivery Since then she had not been able to move her legs and had had paresis of the anal and urinary sphincters and loss of sensibility up to the level of Th8

Gas myelography was performed with a view to possible surgical treatment The vertebral canal in the thoraco-lumbar and sacral regions was markedly dilated The vertebral arches were defective below Th10 and other vertebral anomalies were present No remnant of the external sac of the myelomeningocele was evident and there was no spinal cord in the subarachnoid space below the level of the Th10



a



b

Fig 5 Case 5 a) Lateral tomography Practically total absence of posterior arches with no spinal cord in the subarachnoid space below Th10 b) Lateral tomography of cervical region Arnold Chiari malformation and widening of the spinal canal and the subarachnoid space (Arrows indicate herniated cerebellar tonsils)

A rather thin irregular threadlike formation probably composed of nerve roots and the filum terminale extended down to the lower pole of the subarachnoid space (Fig 5a) no lumbar intumescence or medullary cone was present Fig 5c shows that there was also an Arnold Chiari malformation a frequent finding in cases of myelomeningocele (cf Case 7) *This is considered by some to be due to traction exerted on the spinal* cord by its abnormal fixation at its lower end and by others as a downward herniation of the cerebellar tonsils caused by hydrocephaly during embryonic life Although this patient had been operated upon at the age of 3 days and a large myelomeningocele sac removed the associated malformations of the central nervous system had persisted

Discussion

Gas myelography gives excellent information concerning the anatomical conditions in meningo- and myelomeningoceles It clearly demonstrates such features as absence of the medullary cone, abnormal fixation of the spinal *cord to the wall of the vertebral canal in the proximity* of the meningeal herniation, and the abnormal caudal extension of the cord These all serve to differentiate a myelomeningocele from a simple meningocele, which is a much rarer condition Certain forms of meningocele that are impossible to diagnose with any certainty without myelography or some sort of meningeal

puncture also exist As examples may be cited the intrasacral and anterior sacral (11, 42, 46) and the lateral thoracic (20 37 49) types These rare meningoceles often give rise to no symptoms until adult life, and then they may be operated upon or punctured in the belief that the condition is a cyst or a tumour The consequences of such an erroneous diagnosis may prove tragic (BYRON, ALLING & SAMSON 1949, POHL 1933 SHIDDLER & RICHARDS 1943, WILHELM 1954 inter alios) Recklinghausen s disease attracts special attention in this connection (2 5 6, 8, 12 21, 27, 35 37, 40) It is widely recognized that besides the cutaneous manifestations of the disease, neurinomas often lie inside and outside the spinal canal, sometimes forming so called dumbbell tumours What is perhaps less well known is that two-thirds of patients with a lateral intrathoracic meningocele suffer from Recklinghausen s disease These meningoceles may be detected at routine chest radiography (BUNNER 1959 LUND & POULSEN 1958) and a correct diagnosis of a tumour of the posterior mediastinum made by myelography

An important advantage of gas myelography is that the contrast medium is practically non irritating and non toxic and is quickly absorbed It does not give rise to arachnoiditis or cyst formation, which may be harmful and cause difficulties at subsequent operation or re examination (ERICKSSON & VAN BAAREN 1953, HURTEAU BAIRD & SINCLAIR 1954 SARKISIAN 1956) (and others 4, 9 14 26, 39 43 48) The significance of this is obvious if the fact is borne in mind that droplets of oily contrast media often enter the cranial cavity after myelography

Gas myelography may be recommended as being a safe and informative method for examining meningo and myelomeningoceles

SUMMARY

Characteristi roentgenologic features of a myelomeningocele are described The advantages of gas myelography over myelography with oily contrast media in the examination of meningo- and myelomeningoceles are emphasized

ZUSAMMENFASSUNG

Die typischen Rontgensymptome der Myelomeningocele werden beschrieben Die Überlegenheit der Anwendung der Gasmyelographie — im Gegensatz zu dem Gebrauch von Iodolen — fur die Meningocelen und Myelomeningocelen wird betont

RÉSUMÉ

Description des signes radiologiques caractéristiques des myéloméningocèles L auteur souligne les avantages de la myélographie gazeuse par rapport a la myélographie avec moyen de contraste huileux pour l examen des méningo- et myéloméningoceles

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LES DISCO-SPONDYLITES TRAUMATIQUES

par

J N Taptas et P A Katsiotis

Deux cas de disco spondylite traumatique intéressant le dernier espace lombaire sont presentés, la pathogenie et le traitement sont brièvement discutés

Cas 1 Médecin agé de 40 ans souffrait depuis 9 mois d une sciatique hyperalgique type S1 sur les radiographies un léger pincement du dernier disque lombaire

Les examens de laboratoire notamment la sedimentation globulaire étaient normaux En juillet 1959 nous retirons par la voie latérale une hernie discale qui avait déchiré le liga ment intervertébral postérieur Pas de curetage important de la cavité La sciatalgie disparait aussitôt apres l opération mais quelques jours plus tard apparait un léger fébricule et le malade commençait a se plaindre de lombalgie irradiant vers la fesse gauche du côté opposé à la hernie Nous constations alors l existence d une collection séro-hématique au niveau de la plaie et nous la drainions Malgré la cicatrisation de la plaie opératoire et en l absence d infec tion le fébricule et les douleurs persistaient Le malade prenait de sa propre initiative de très fortes doses d antibiotiques associés aux sulfamides

La sédimentation globulaire 20 jours après l opération était très accélérée Progressivement la température redevient normale les douleurs s atténuent et le malade quitte l hôpital un mois apres l opération et reprend ses activités

Trois mois plus tard la douleur lombo-fessière réapparait et un contrôle radiographique (Fig 1 a et b) montre l exagération du pincement discal L5—S1 avec de plus érosions et flou des plateaux vertébraux adjacents qui paraissent par ailleurs condensés La tomographie confirme ces lésions L examen ne montrait qu une rigidité des muscles lombaires, la vitesse de sédimentation étant encore légèrement accélérée Nous portions alors le diagnostic de disco-spondylite traumatique post-opératoire et un traitement par delta-cortisone et radio thérapie aux doses anti inflammatoires est institué Les douleurs disparaissaient totalement en 15 jours environ et le malade reste depuis guéri



Fig 1 Cas 1 a) et b) Aspect évolutif Pincement L5—S1 avec érosion et condensation des plateaux vertébraux adjacents c) et d) Aspect définitif cicatriciel pont ostéo-fibreux entre L5 et S1

Un controle radiographique effectué quatre mois plus tard a montré la reconstitution des plateaux vertébraux condensés Une année plus tard les clichés montraient la disparition presque complete de l espace lombo-sacré avec ponts ostéo-fibreux (Fig 1 c et d)

Cas 2 Homme agé de 39 ans a souffert en 1952 d une lombalgie aigue apres un effort violent Un an plus tard récidive de la lombalgie Une troisième récidive survient en décembre 1959 après un nouvel effort Cette fois ci contrairement aux crises précédentes la douleur ne cede pas au repos et aux traitements habituels mais s exagère progressivement Il souffre surtout dans la position assise avec parfois irradiations au bas ventre pas d irradiations aux membres inférieurs Il n'existe aucun antécédent infectieux dans le passé du malade



a b

Fig 2 Cas 2 Aspect evolutif Pincement de L5—S1 condensation des plateaux vertébraux adjacents avec erosions s étendant jusque sur la face antéro inferieure de L5

Des radiographies de la colonne lombaire faites 5 mois après l effort déclenchant la dernière récidive montrent un pincement du dernier espace lombaire avec condensation et destruction des plateaux avoisinants (Fig 2) La 5ème vertebre lombaire apparait sur le profil de forme trapézoidale La tomographie confirme ces lésions

Cinq mois plus tard la répétition des clichés montre un aspect sensiblement analogue Quand nous voyons le malade dix mois après le début de la crise l examen neurologique est normal il existe seulement une rigidité des muscles lombaires et une limitation des mouvements de flexion antérieure du tronc La sédimentation globulaire est normale ainsi que les divers examens de laboratoire

Nous portons le diagnostic de disco-spondylite traumatique et conseillons un traitement par radiothérapie aux doses anti inflammatoires Ce traitement à peine commencé le malade part a Vienne ou une myélographie est pratiquée qui montre l intégrité du canal rachidien A ce moment il existe déja sur le profil un pont ostéo fibreux lombo-sacré Le malade est ensuite soigné par des agents physiques avec de bons résultats Nous l avons revoyé un an et demi après notre premier examen il ne souffre pratiquement plus et mène une vie normale

Commentaires

Chez des malades souffrant principalement de lombalgie le diagnostic d une disco spondylite traumatique ne peut etre pose que par la constatation de modifications radiologiques intéressant un des derniers disques lombaires et des plateaux vertébraux adjacents Il s'agit d un pincement discal avec reaction mixte de condensation et de destruction (microgéodes) des plateaux vertébraux avoisinants sans reaction des parties molles Toutefois ces modifications radiologiques ne permettent pas à elles seules de porter un diagnostic étiologique qui sera discuté differemment selon les circonstances d apparition des lesions disco vertébrales

Quand la lésion disco vertébrale survient apres une intervention pour hernie discale c est avant tout le diagnostic de disco spondylite infectieuse qui sera discutee De telles infections post opératoires bien que rares, peuvent compliquer une intervention discale (ARMSTRONG LENSCHOEK) Elles s ac *compagnent toutefois de manifestations infectieuses aigués de tres fortes* douleurs rachidiennes avec généralement des irradiations radiculaires parfois des reactions meningées Il s agit d ostéomyélites vertébrales post opératoires

Le tableau de notre malade (Cas I) était bien different Nous pensons que dans son cas il s agissait de réaction inflammatoire aseptique du disque et des plateaux vertebraux adjacents et que chez notre malade comme dans les cas analogues publiés en 1958 par SCHULTZ, l operation a agi uniquement comme agent traumatisant Il s agit d une complication tres rare de la chirurgie discale (1 cas personnel sur plus de 300 opéres)

Quand les lésions disco vertébrales surviennent independamment de toute intervention (Cas 2) et en l absence d infection notamment urinaire une disco spondylite tuberculeuse plus qu une ostéomyélite peut etre discutee L absence de reactions des parties molles sur les radiographies la stabilité des lesions a des examens successifs, la sedimentation globulaire normale ainsi que la notion de traumatisme déclenchant nous ont permis d éliminer le diagnostic de tuberculose

Des aspects radiologiques analogues ont éte publiés par DE SEZE et coll comme formes pseudo pottiques de l arthrose lombaire Nous pensons cependant que le processus est beaucoup plus disco vertébral qu articulaire et que dans tous ces cas l atteinte initiale du disque et des plateaux vertébraux adjacents telle que l exteriorise la radiographie, est la consequence d une hyper hemie inflammatoire aseptique d'origine traumatique C est pourquoi l appellation de disco spondylite traumatique nous parait préferable a celle de discarthrose pseudo pottique

La pathogenie neuro vasculaire de ces lésions peut etre comparée a celle des réactions post traumatiques decrites au niveau des extrémites par Sudeck et Leriche Il est tres probable que des reactions neuro vasculaires pathologiques ne surviennent que sur des terrains particuliers ce qui explique leur relative rarete

Sur le plan thérapeutique nous pensons que la radiothérapie aux doses anti inflammatoires préconisee par SCHULTZ associee si besoin a la cortisone constitue le meilleur traitement Si la sedation des douleurs peut etre rapide sous l influence du traitement l évolution anatomo pathologique est assez longue mais se fait vers la cicatrisation ostéo fibreuse des lesions disco vertebrales

Il nous parait inutile d insister sur l interet qu il y a a reconnaitre plus precocement possible ces disco spondylites traumatiques afin d éviter sur le seul aspect radiologique des lesions des diagnostics entrainant une immobilisation exagerée ou des interventions inutiles

RÉSUMÉ

Les auteurs présentent deux observations personnelles de disco spondylite traumatique dont l une post opératoire Le diagnostic n a pu être posé que par la constatation radiologique de modifications caractéristiques au niveau du disque et des plateaux vertébraux adjacents. Le diagnostic différentiel la pathogénie et le traitement de ces disco-spondylites traumatiques sont envisagés

SUMMARY

Two cases of traumatic diskospondylitis one of which was subjected to operation are described The diagnosis was made possible by characteristic roentgenologic changes in the disk and adjacent vertebral surfaces The pathogenesis differential diagnosis and treatment of the condition are discussed

ZUSAMMENFASSUNG

Zwei Falle von traumatischer Diskospondylitis von denen einer operiert wurde werden berichtet Die Diagnose wurde durch typische Rontgenveranderungen an der Bandscheibe und den angrenzenden Wirbeloberflachen ermoglicht Die Pathogenese Differenzialdiagnose und Therapie des Krankheitsbildes werden besprochen

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DEFINITION DU DEPLACEMENT ANTERO-POSTERIEUR DE LA DENT DE L'AXIS A L'AIDE DE LA LIGNE BASILAIRE

par

F Thiebaut A Wackenheim et C Vrousos

L etude radiologique des deplacements de l apophyse odontoide prend une importance particuliere en raison de la gravite des troubles nerveux concomitants Ces deplacements de l odontoide, qu ils soient congénitaux ou traumatiques comportent obligatoirement une definition dans les trois dimensions de l espace Si les deplacements lateraux sont relativement faciles a reconnaitre par tomographie frontale les déplacements verticaux sont definis par des lignes reperes dont la ligne de Chamberlain est indiscutablement la plus utile

Le diagnostic des deplacements antéro-posterieurs s avere toutefois delicat C est pourquoi nous avons proposé l utilisation d une ligne basilaire qui indique la situation normale du pole postéro superieur de l apophyse odontoide sans introduire de mensuration quelconque La ligne que nous utilisons est la prolongation linéaire du plan basilaire lorsque sa projection de profil est rectiligne Dans les cas de plan basilaire concave ou convexe on reunit les extremités des courbures pour tracer la ligne (Fig 1) Nous utilisons un tomogramme sagittal médian pratique en position assise physiologique avec appui occipital (craniographe Dulac)



Fig 1 Schéma démontrant comment tracer la ligne basilaire

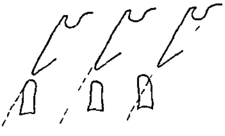


Fig 2 Trois variétés de position odontoïdienne Dent de l axis en situation normale par rapport à la ligne basilaire (a) en avant de la ligne basilaire — luxation postérieure de l occipital (b) et en arrière de la ligne basilaire — luxation antérieure de l occipital (c)

En presence d une anomalie congenitale ou traumatique de la charniere cervico occipitale nous definissons la situation antéro posterieure de la dent par rapport au corps de l axis en bas et par rapport a la ligne basilaire en haut Ce dernier repere permettra ainsi de distinguer trois variétés de position odontoidienne indépendamment des anomalies osseuses associées (Fig 2)

Les cliches radiographiques illustrant de tels deplacements sont reproduits dans les articles indiques dans la bibliographie

RÉSUMÉ

Les auteurs insistent sur les difficultés du diagnostic des déplacements antéro-postérieurs de la dent de l axis (l apophyse odontoide) et proposent l utilisation d une ligne basilaire pour définir ces déplacements

SUMMARY

A method of tracing a basilar line has been found useful in the diagnostic evaluation of antero posterior displacements of the odontoid process of the axis

ZUSAMMENFASSUNG

Eine Methode zur Bestimmung der Basilar Linie hat sich wertvoll erwiesen in der Diagnose der antero posterioren Dislokation des Odontoid Prozessus des zweiten Halswirbels

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Fig 1 Schema demontrant comment tracer la ligne b silaire

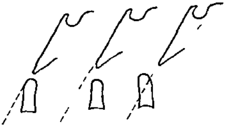


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RÉSUMÉ

Les auteurs insistent sur les difficultés du diagnostic des déplacements antéro-postérieurs d la dent de l axis (l apophyse odontoide) et proposent l utilisation d une ligne basilaire pou définir ces deplacements

SUMMARY

A method of tracing a basilar line has been found useful in the diagnostic evaluation antero posterior displacements of the odontoid process of the axis

ZUSAMMENFASSUNG

Eine Methode zur Bestimmung der Basilar Linie hat sich wertvoll erwiesen in der Diagn der antero posterioren Dislokation des Odontoid Prozessus des zweiten Halswirbels



Fig 1 Case 1 Gross backward displacement of the fourth ventricle — crescentic shape

headaches and vomiting He was also unsteady on his feet He was admitted to the National Hospital (under the care of Carmichael) at the age of 9 years

On examination a gross papilloedema was found nystagmus to both sides slight right lower facial weakness palatal deviation to the left and pharyngeal anaesthesia on the right There was a slight weakness of the right sterno-mastoid and trapezius and the tongue deviated to the right but there was no atrophy or fibrillation The limbs showed flaccidity and gross cerebellar incoordination more marked on the right The plantar responses were flexor The gait showed extreme ataxia of the cerebellar type

Ventriculography was performed and showed a well developed symmetrical hydrocephalus of the lateral and third ventricles with gross backward displacement of the fourth ventricle (Fig 1) A diagnosis of brain stem tumour was made and the patient was discharged

The patient was re admitted in April 1949 now aged 12 having become blind and showing bilateral secondary optic atrophy a slurred dysarthria and a divergent squint The tongue now protruded in the midline The plantar responses had become bilaterally extensor and the skull had a crackpot note on percussion

Repeat ventriculography was performed The appearances were very similar to those of the last examination except for the fact that the fourth ventricle was now displaced even further backwards (Fig 2a) Not being satisfied with the diagnosis we decided to introduce Myodil which was readily manipulated into the fourth ventricle A small portion passed more ventrally than the air had done and outlined part of the floor of the fourth ventricle (Fig 2b) A diagnosis of intraventricular tumour was made

Operation The surface of a purplish grey tumour presented in the midline near the foramen magnum The vermis was split and the tumour was seen to separate from cerebellar tissue and part of the tumour was removed as the fourth ventricle was entered It was stated in the operation report (McKissock) that the tumour was not truly intraventricular but had arisen close to the ventricular wall on the right side It was removed in small pieces and the total specimen weighed 50 5 g Section showed an astrocytoma with nuclei varying in size shape and staining density but without mitoses

Post mortem A large cavity replaced the tumour which had been removed from the floor of the fourth ventricle The pons was slightly enlarged and firm section showed invasion by



a b

Fig 2 Same case as in fig 1 a) Repeat ventriculography 3 years later Slight increase in backward displacement of the fourth ventricle b) Myodil ventriculography Small quantity of the contrast medium (arrow) along the floor of the much enlarged ventricle large filling defect within the ventricle suggesting intraventricular tumour

astrocytoma No mitoses were found but the cells were pleomorphic and classifed as grade II or grade III astrocytoma (Blackwood)

Case 2 Man aged 25 was admitted to our hospital in December 1946 (under the care of Sir Charles Symonds) He had recently been discharged from the Royal Air Force and gave a history of 18 months headache on waking in the morning This headache was a vertical pressure sensation which gradually passed off in about two hours If he had breakfast while the headache was present he nearly always felt sick and vomited the headache tended to be relieved by vomiting He otherwise felt well but during the past four months he had noticed that he deviated in his course when walking sometimes to the right and sometimes to the left.

The positive physical signs on examination were bilateral papilloedema first degree nystagmus to the right very slight suspicion of right lower facial weakness minimal impairment of coordination of left hand minimal impairment of coordination for the knee ankle test on the left difficulty in standing on one leg There was no obvious ataxia but while walking and attempting to toe a line he was very unsteady Conventional roentgen examination of the skull revealed no abnormality and a lumbar puncture showed a pressure of 300 mm of water but no other abnormality Clinically it was thought possible that a midline cerebellar tumour was present perhaps an astrocytoma and surgical investigation was recommended

Ventriculography Both lateral ventricles were tapped and the fluid was under considerable pressure The films showed a gross symmetrical hydrocephalus of the lateral and third ventricles and gross backward displacement of the floor of the fourth ventricle A diagnosis of a pontine or pre pontine mass was made (Fig 3a) The patient was referred for roentgen therapy

The patient was re admitted 3 years later and had not improved after the roentgen treatment he had been unable to return to work In the last six months his condition had de-



a b



c

Fig 3 Case 2 a) The fourth ventricle is of similar appearance as in fig 1 b) and c) Myodil ventriculography Similar appearances as in fig 2b arrow indicates Myodil on floor of fourth ventricle

teriorated considerably his gait having become more and more ataxic so that he could not walk without assistance His hands had become extremely incoordinate and the headache had returned His eyesight had remained unchanged On examination he was slow in his responses and his voice was slurred and irregular There was slight swelling of both discs and his visual acuity was 6/18 and 6/12 when corrected There was an irregular and gross nystagmus to the left and a few jerks to the right together with gross cerebellar incoordination

Ventriculography with Myodil (Fig 3 b and c) was undertaken and the fourth ventricle was outlined It was shown to contain a gross filling defect and as in the previous case some Myodil entered the anterior part of the fourth ventricle which air had failed to outline

Operation (McKissock) A large granular tumour lying in the cavity of the fourth ventricle was completely removed On microscopic examination it proved to be a choroidal papilloma (Blackwood) The patient recovered from the operation without incident and later returned to work. Since that time now twelve years ago he has remained well

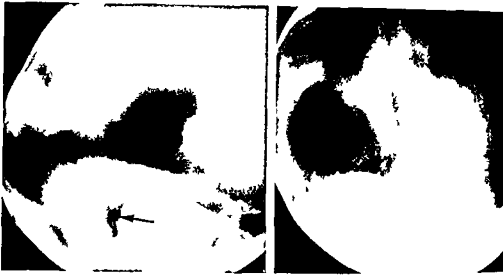


Fig 4 Case 3 Displaced and distorted fourth ventricle

Case 3 A boy aged 16 years was admitted in July 1960 He complained of intermittent unsteadiness in walking for three months and intermittent headaches for six weeks The staggering gait came on quite suddenly three months previously was episodic and was precipitated by stooping About six weeks later bifrontal headaches had developed which radiated towards the occipital region They occurred most commonly on waking and usually only lasted about ten minutes The parents stated that about nine months previously he had had some attacks of vomiting in the mornings but these had not occurred during the last six months On one occasion during unsteadiness in walking his speech was slurred for a few seconds On another occasion when he had the headache he stated that his right arm and leg had become numb

On examination bilateral papilloedema with haemorrhages was present There was a slow first degree nystagmus to left and right The clinical impression was that a posterior fossa tumour such as a medulloblastoma was probably present though benign intracranial hypertension could not be ruled out Conventional roentgen films of the skull showed a very early pressure atrophy of the sella and no other abnormality

Ventriculography The brain was found to be under considerably increased tension Both lateral ventricles were considered to be larger than normal A catheter was inserted into the right lateral ventricle and three days later 40 ml of air were injected The cerebrospinal fluid contained nothing remarkable and the Wasserman reaction was negative Considerable enlargement of the lateral and third ventricles was disclosed and backward displacement of the fourth ventricle by at least 1 cm (Fig 4) was present Since there was no clinical evidence to support a diagnosis of brain stem neoplasm and being reminded of the other two cases it was considered important to attempt to outline the floor of the fourth ventricle by introducing air from below Even if only a minute quantity of air entered this part of the ventricle and was hidden by the mastoids it was hoped that the method of autotomography (not known to us in 1949) might give some complementary information

Lumbar encephalography was therefore performed about 12 ml of air were introduced but none entered the ventricles The ambient cisterns were filled and appeared normal Thus no further useful information was obtained



a b

Fig 5 Same case as in fig 4 a) Myodil ventriculogram Filling defect within cavity of fourth ventricle b) Autopsy specimen much of the tumour was removed at operation

Myodil ventriculography was next undertaken by introducing 2 ml Myodil into the lateral ventricle and manipulating it into the fourth ventricle Some of the contrast medium passed along the floor of this ventricle and showed that it was in fact situated more anteriorly than normal indicating a forward compression of the pons There was a large lobulated filling defect in the fourth ventricle measuring about 2 5 cm in diameter (Fig 5a) It was concluded that an intraventricular tumour was present and operation was recommended

Operation (McKissock) The cisterna magna was approached through a midline incision Before the dura was opened it was seen to be grossly bulging When it was opened a brownish pink tumour mass was exposed widely separating the cerebellar tonsils and pushing the vermis upwards The tumour was soft and extremely vascular One portion was sent for immediate section The tumour was removed by suction and by the help of a pituitary rongeur It was found to be extremely large extending up into a grossly dilated fourth ventricle and deriving its blood supply anteriorly and inferiorly on each side Although most of the tumour was removed without difficulty a thin film was adherent to the floor of the fourth ventricle in its lower half and here of course radical excision was impossible This film of tumour appeared to be not more than 1 mm thick but would not separate from the brain stem When all haemorrhage had been arrested an excellent view of the fourth ventricle and aqueduct could be obtained The dura was then closed The patient died the following day

Microscopy The tumour was a glioma of ependymal type weighing 10 9 g The tumour cells were predominantly perivascular the nuclei being separated from the vessels by a granular fibrillar eosinophilic material A few mitoses were seen Diagnosis Ependymoma grade II (Blackwood) A sagittal section of the autopsy specimen is seen in Fig 5b

Discussion and Conclusions

The three tumours described were all situated for the most part within the cavity of the fourth ventricle In fact, unfortunately only one of the three lay entirely within the fourth ventricle it was benign (a choroid plexus papilloma),

was removed surgically and the patient was cured The other two patients failed to survive because in each case a small portion of tumour infiltrated the brain stem There appears to be no radiologic means of always differentiating a mass which lies entirely within the fourth ventricle from one which has some attachment to the floor Even if a slight attachment is shown radiologically, it would be unwise on that score alone to state dogmatically that the tumour is inoperable The point remains valid that it is important always to make every attempt to outline the floor of the fourth ventricle when hydrocephalus is present even if at air ventriculography the floor is not shown In such cases it would seem to the author imperative to use a positive contrast substance if air encephalography and autotomography also fail to outline the floor of the fourth ventricle, as happened in Case 3

SUMMARY

It is occasionally difficult to differentiate intra fourth ventricle tumours from brain stem masses Air ventriculography may give a misleading picture and encephalography may fail to outline the fourth ventricle In such circumstances ventriculography with the use of a positive contrast medium is indicated

ZUSAMMENFASSUNG

Es ist gelegentlich schwierig Tumore des vierten Ventrikels von solchen des Gehirnstammes zu *differenzieren Luftventrikulographie kann irreführende* Bilder ergeben und Enzephalographie kann hinsichtlich der Darstellung des vierten Ventrikels misslingen In solchen Fallen ist eine Ventrikulographie mit positivem Kontrastmittel indiziert

RÉSUMÉ

Il est parfois difficile de distinguer les tumeurs du quatrième ventricule de celles du tronc cérébral La ventriculographie gazeuse peut donner des images trompeuses et l encéphalographie peut etre incapable de dessiner le quatrième ventricule Dans ces cas la ventriculographie avec moyen de contraste positif est indiquee

FROM THE ROENTGEN DEPARTMENT (DIRECTOR A LEPE), THE INSTITUTE OF NEUROSURGERY, SANTIAGO, CHILE

CEREBRAL TUBERCULOMA

by

MARIO CASTRO and ALFREDO LEPE

The granulomatous localization in the brain of the tubercle bacillus (tuberculoma) is a condition that occurs with relative frequency in countries with a high incidence of tuberculosis Cerebral tuberculomas constitute 5 6 % of all intracranial expansive processes in the material of our institute

Material The material consists of 96 cases of cerebral tuberculoma admitted to the institute from 1940 to 1960 that were verified by necropsy or operation and in which *some form of roentgenologic examination was performed* Conventional roentgenography of the skull was carried out in 73 cases ventriculography in 67 encephalography in 7, and carotid arteriography in 16 cases There were 16 multiple and 80 solitary tuberculomas in the material, distributed as follows

A *Infratentorial* (43 cases)

Cerebellar hemispheres	32
Vermis	6
Medulla and pons	5

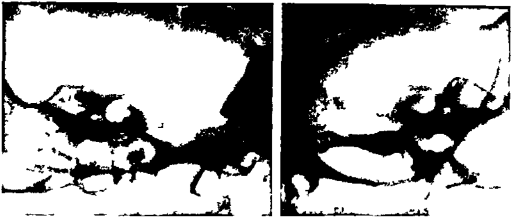


Fig 1 Left cerebellar hemisphere tuberculoma Bone defect in antero-inferior part of right apex of petrous bone Dilatation of right internal auditory meatus

B *Supratentorial* (37 cases)

Frontal lobe	11 (including one tuberculous abcess)
Parietal lobe	4
Temporal lobe	2
Occipital lobe	1
Fronto parietal	5 (including one tuberculous abcess)
Fronto temporal	2
Parieto occipital	2
Parieto occipito temporal	4
Basal ganglia	3
Mesencephalon	2
Sellar diaphragm	1

The multiple tuberculomas were in most of the cases situated both in the supratentorial and infratentorial fossae The age of the subjects varied between 1 year and 7 months and 58 years, the majority of cases occurring in the three first decades of life (76 cases)

Ventriculography was performed in the classic Lysholm positions and encephalography with the standard technique of replacing a given volume of spinal fluid by air and obtaining films in the Lysholm positions Arteriography was carried out by percutaneous puncture of the carotid artery the injection of Nosylan (Diodrast) 45 %, and films in the arterial phases only

Results

Evidence of intracranial hypertension in the sella turcica in adults and the separation of the sutures in children, were the most important roentgenologic findings in the ordinary films of the skull (73 cases) (Table 1)



Fig 2 Right fronto-parietal tuberculous abscess in a p view Decalcification of the right greater and lesser wings of the sphenoid

Other signs of increased intracranial pressure when associated with the former, were also valuable Increased convolutional digitations were found in 12 cases (16 43 %) Localized changes were evident in 3 cases in two of which there was erosion of the apex of the petrous bone, homolateral in one and contralateral in the other case to a tuberculoma of a cerebellar hemisphere (Fig 1) The third case was one of a fronto-parietal tuberculous abcess in which there was decalcification of the greater and lesser wings of the sphenoid on the same side as the lesion (Fig 2) Calcification of the tuberculoma was present in only one case of our series (Fig 3)

Ventriculography revealed hydrocephalus in every one of the 67 cases of infratentorial granuloma (Table 2) Evidence of an expansive process was present in every case of the group of supratentorial tuberculomas but hydrocephalus was found in only 10 cases (38 4 %) Ventriculography established the diagnosis of a cystic expansive process in one of these, a case of a tuberculous abscess (Fig 4) The ventricular changes evident in multiple tuberculomas with signs of expansion (12 cases) were conditioned by the largest granuloma (7 cases)

Encephalography was performed in 7 cases but the technique used the roentgenograms obtained and the limited number of cases, do not permit any conclusions to be drawn

Table 1

Findings at conventional roentgenography of the skull in tuberculoma of the brain

Site of tuberculoma	Number of cases	Normal skull	Signs of increased intracranial pressure	Intracranial calcifications	Hydrocephalic skull
Solitary infratentorial	34	10 (29 4 %)	24 (70 5 %)	—	5
Solitary supratentorial	26	7 (26 9 %)	[illegible] (73 %)	1	—
Multiple	13	7 (53 8 %)	6 (46 1 %)	—	1
Totals	73	24 ([illegible] 8 %)	43 ([illegible] 1 %)	1	[illegible]



Fig 1 Left cerebellar hemisphere tuberculoma Bone defect in antero inferior part of right apex of petrous bone Dilatation of right internal auditory meatus

B *Supratentorial* (37 cases)

Frontal lobe	11	*(including one tuberculous abcess)*
Parietal lobe	4	
Temporal lobe	2	
Occipital lobe	1	
Fronto parietal	5	(including one tuberculous abcess)
Fronto temporal	2	
Parieto occipital	2	
Parieto occipito temporal	4	
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Solitary infratentorial	34	10 (29 4 %)	24 (70 5 %)	—	5
Solitary supratentorial	26	7 (26 9 %)	19 (73 %)	1	—
Multiple	13	7 (53 8 %)	6 (46 1 %)	—	1
Totals	73	24 (32 8 %)	49 (67 1 %)	1	6



Fig 3 Right temporo-parietal tuberculoma half axial view in supine position Conglomerate of nodular calcifications distributed in an arch concave inwards

Carotid angiography was carried out in 14 cases of which eleven were cases of supratentorial solitary tuberculoma, and two were cases of infratentorial tuberculoma All of the former presented evidence of an expansive process One was a case of a parietal tuberculous abscess which in the arteriogram appeared as a rounded intracerebral mass (Fig 5) Arteriography disclosed hydrocephalus in the two cases of infratentorial granuloma

Discussion

The literature on this subject is scanty and attention has generally been centered on calcification of the granuloma

Our findings are rather different from those reported by other authors The presence of signs of intracranial hypertension was in our material too frequent to be overlooked Of the 73 cases, in which a conventional examination of the skull was performed, signs of intracranial hypertension were found in 49 (67 12 %) RAMAMURTHI & VARADARAJAN, in a series of 200 cases, gave a

Table 2

Ventricular changes observed in tuberculoma of the brain

Site of tuberculoma	Number of cases	Normal sized ventricles	Hydrocephalus	Ventricles in normal position	Signs of expansive process
Solitary infratentorial	29	—	29 (100 %)	8 (27 5 %)	21 (72 4 %)
Solitary supratentorial	26	16 (61 5 %)	10 (38 4 %)	—	26 (100 %)
Multiple	12	4 (33 3 %)	8 (66 6 %)	5 (41 6 %)	7 (58 3 %)
Totals	67	20 (29 8 %)	47 (70 1 %)	13 (19 4 %)	54 (80 5 %)



Fig 4 Left frontal tuberculous abscess ventriculography Displacement of lateral ventricles septum pellucidum and third ventricle in an arch concave to the left

figure of 40 (20 %) Calcification of the tuberculoma, reported by some authors in about 6 % of cases (EVANS & COURVILLE, RAMAMURTHI & VARADARAJAN) was however present only in one of our cases (1 36 %) and had extracranial tuberculosis not been present in this case the etiologic origin of the calcified mass would probably have been missed Our finding is in agreement with the report of SCOTT & GRAVES who made a survey of the literature on cerebral tuberculoma and in a total of 815 cases found calcification of the lesion in only 11 (1 3 %)

The differences between our observations and those of other authors may be due to biologic factors The high percentage of changes caused by intracranial hypertension and the extremely few calcified lesions in our material, may have been the result of all, or almost all of our cases having active and progressive forms of tuberculosis Calcification indicates a curative process in a terrain endowed with a certain resistance to Koch s bacillus

Ventriculography disclosed hydrocephalus in all cases of solitary tuberculoma of the posterior fossa (100 %) and evidence of an expansive process (72 41 %) Signs of expansion were always present in supratentorial granuloma (100 %) and of hydrocephalus in 10 cases only (38 46 o' latter being produced by the situation of the lesion and its obstruction spinal fluid circulation and in some cases being due to a concomitant culous leptomeningitis

SUMMARY

The roentgenologic appearances of cerebral tuberculoma in a material of 96 cases in which conventional roentgenography ventriculography and encephalography were employed are analyzed Calcification was present only in one case and it is concluded that there are no particular signs other than those of a neoplastic process to indicate this condition

ZUSAMMENFASSUNG

Sechsundneunzig Falle von Gehirntuberkulom wurden mit gewöhnlichen Rontgenaufnahmen und mit Enzephalographie bezw Ventrikulographie untersucht und die Befunde wurden analysiert Nur ein einziger Fall zeigte Verkalkung und man muss zu dem Schluss kommen dass keine charakteristischen Zeichen bestehen die ein Tuberkulom von einem anderen Prozess unterscheiden

RÉSUMÉ

Les auteurs décrivent les signes radiologiques du tuberculome cérébral dans une série de 96 cas ou la radiographie simple la ventriculographie et l encéphalographie ont été pratiquées Il n y avait de calcification que dans un seul cas le tuberculome cérébral n a donc pas de signes radiologiques particuliers et se manifeste seulement comme une néoformation cérébrale

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a b

Fig 1 a) Tumeur hémisphérique cérébelleuse le produit opaque visualise l aqueduc qui est refoulé vers l avant mais il ne pénètre pas dans le IVe ventricule b) Cliché pris 30 minutes après (a) Le IVe ventricule est bien visualisé et nettement refoulé vers l avant

Nous réservons l iodoventriculographie comme examen initial pour les patients soupçonnes de tumeur de la fosse posterieure et souffrant d hyper tension intracranienne Dans les autres cas elle n est utilisée que tres rarement et uniquement pour preciser des lésions mal mises en evidence par l air, ou dans certains cas de stenose

Si le transit iode est fort ralenti nous avons l habitude de pratiquer un drainage ventriculo sous cutane, suivant la technique de Dereymaeker cette intervention fort bénigne, est tres utile elle soulage grandement le malade et le met a l abri d une poussee hypertensive L opération définitive se fera egalement dans des conditions meilleures

La technique que nous utilisons est toujours la meme que celle que nous avons decrite en 1958 Chez les jeunes enfants toutefois cette technique est difficile Aussi nous nous contentons d'injecter l huile iodee dans la corne frontale l enfant etant assis, la tete fortement fléchie sur la table en position horizontale Ensuite, nous couchons lentement l enfant tout en gardant sa tete flechie et nous prenons rapidement des clichés de face et de profil

Lorsque le quatrième ventricule parait refoulé vers l arriere il est indispensable de coucher le patient sur le ventre afin d eliminer un simple moulage de la paroi posterieure d un ventricule dilate Mettre le patient sur le ventre exige certaines precautions pour empecher l huile iodee de retourner dans le systeme ventriculaire lateral Nous avons l habitude de redresser la table, de mettre les patients à genoux sur la banquette, puis de recoucher la table les malades sont ainsi en decubitus ventral menton table On peut alors distinguer un vrai deplacement vers l arriere du quatrieme ventricule des fausses images provoquées par l hydrocéphalie

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L'IODOVENTRICULOGRAPHIE DANS LES AFFECTIONS DE LA FOSSE POSTERIEURE

par

G. CORNELIS et A. DEREYMAEKER

L'iodoventriculographie, dont nous avons retracé, il y a quatre ans déjà, suite aux travaux de BULL, l'utilité dans le diagnostic des lésions de la fosse *postérieure semble perdre lentement le préjugé très défavorable* qui lui était attaché. Sans vouloir passer en revue tout l'historique de l'iodoventriculographie, nous noterons quand même que cette technique est maintenant couramment utilisée par de nombreux neurochirurgiens pour les interventions stéréotaxiques. Depuis nos dernières publications, des travaux fort intéressants ont été faits par JEFFERSON, DILENGE, DAVID et TALLAIRACH. Notre statistique s'élève actuellement à 404 iodoventriculographies, dont 170 tumeurs de la fosse postérieure. Nous croyons pouvoir dire que cette méthode est parfaitement valable pour affirmer l'existence d'une lésion de la fosse postérieure et en préciser la localisation: elle visualise toujours la lésion de manière précise et on ne risque donc pas de faire subir au patient un examen qui *ne donne* pas de résultats probants.

Comparer les dangers de diverses méthodes est fort difficile, mais nous devons faire remarquer que c'est l'iodoventriculographie qui nous donne les meilleurs résultats avec le minimum d'inconvénients pour le patient, surtout si celui-ci est atteint d'une forte hypertension intracranienne, cas dans lequel nous hésitons à pratiquer une encéphalographie, *qu'elle soit* fractionnée ou progressive.



a b

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Si le transit iodé est fort ralenti, nous avons l habitude de pratiquer un drainage ventriculo sous cutane suivant la technique de Dereymaeker cette intervention fort benigne est tres utile elle soulage grandement le malade et le met a l abri d une poussee hypertensive L operation definitive se fera egalement dans des conditions meilleures

La technique que nous utilisons est toujours la meme que celle que nous avons décrite en 1958 Chez les jeunes enfants toutefois cette technique est difficile Aussi nous nous contentons d injecter l huile iodée dans la corne frontale l enfant etant assis la tete fortement flechie, sur la table en position horizontale Ensuite nous couchons lentement l enfant tout en gardant sa tete flechie et nous prenons rapidement des cliches de face et de profil

Lorsque le quatrieme ventricule parait refoulé vers l arriere, il est indispensable de coucher le patient sur le ventre afin d eliminer un simple moulage de la paroi posterieure d un ventricule dilate Mettre le patient sur le ventre exige certaines précautions pour empecher l huile iodée de retourner dans le systeme ventriculaire lateral Nous avons l habitude de redresser la table, de mettre les patients a genoux sur la banquette, puis de recoucher la t… les malades sont ainsi en decubitus ventral, menton table On peut distinguer un vrai deplacement vers l arriere du quatrieme ventricule, des fausses images provoquees par l hydrocephalie



Fig 2 Tumeur hémisphérique cérébelleuse antérieure provoquant une discrete torsion du IVe ventricule

Parfois nous prenons des clichés en position de Hirtz cette position ne doit etre utilisee qu avec une tres grande prudence Il ne faut interpréter qu avec tres grande circonspection les images lacunaires surtout celles situées dans le quatrieme ventricule Il est indiqué de prendre des clichés à des moments differents et en position différentes La radiocinématographie est ici tres utile Toutefois cette methode nous a permis de mettre de toutes petites tumeurs du quatrieme ventricule en evidence

Dans notre groupe de 404 iodoventriculographies, il y a 170 cas de tumeurs ou lesions sous tentorielles, les autres cas sont soit des examens pour stéréotaxie, pour l'étude des lesions medianes supra tentorielles, soit des examens negatifs

Nous classons les lésions en trois groupes tumeurs parenchymateuses extraparenchymateuses et lesions stenosantes

Les lesions *intraparenchymateuses* se divisent en

Lesions du tronc cerébral (47 cas) 2 tumeurs pedonculaires, 15 protubérantielles, 3 bulbaires, et, dans un groupe a part, 27 lésions du IVieme ventricule

Lesions du cervelet (46 cas) 40 lésions hémisphériques et 6 vermiennes

Les lesions *extraparenchymateuses* se divisent en

Neurinomes du VIII 31 cas

Meningiomes 4 cas

5 cas divers tumeurs embryonnaires, métastases etc

Nous avons eu 37 cas de *lesion stenosantes* dont 14 sténoses de l'aqueduc



a b

Fig 3 a) Neurinome du nerf VIII refoulant le IVe ventricule vers l avant b) Image de face

Lésions du tronc cerebral

Si les lesions du tronc cérebral sont fréquemmment diffuses, il est parfois possible de preciser l origine de la lesion Dans les cas de tumeur pédonculaire, on constate un déplacement de l aqueduc en arriere du point de Lysholm De face, l aqueduc est fort peu dévié Dans les cas de tumeur protubérantielle, le plancher du IVe ventricule est situé en arrière du point de Twining et l angle ventriculaire de Sutton est augmenté Le point de Lysholm est en place La cavité ventriculaire est géneralement peu déformée, en dehors de l espace bombé du plancher

Les tumeurs bulbaires genent précocement le transit liquidien Elles refoulent le bord posterieur du bulbe, derriere le point de Gonsette De face la tumeur est souvent moulée par le Lipiodol Les images produites par les tumeurs du IVe ventricule sont fort variables Le ventricule apparait déformé par la tumeur et celle ci est moulee par le Lipiodol Parfois le moulage de la tumeur n est qu unilatéral, il convient de ne pas confondre cette image avec celle d un refoulement latéral du IVe ventricule Les clichés en decubitus ventral sont tres utiles de meme que des cliches en diverses positions pour mieux mouler la tumeur et pouvoir mettre son point d attache en evidence

Lesions du cervelet

Les tumeurs cérebelleuses hémisphériques provoquent un refoulement important du IVe ventricule et de l aqueduc vers l avant l angle ventriculaire est tres pince et la partie postérieur du IIIe ventricule est déplacee vers le haut et vers l avant, de façon plus marquée que dans toute autre tumeur de la fosse posterieure



Fig 4 Neurinome du nerf VIII refoulant le IVe ventricule vers l arriere et provoquant une torsion et un etirement de l aqueduc



Fig 5 Récidive de neurinome du nerf VIII refoulant le IVe ventricule vers l arriere Image de moulage tumoral

De face, on constate une deviation de l aqueduc et du IVe ventricule Si la torsion du IVe ventricule est decrite dans les cas de tumeur de l angle, nous avons cependant constate que les tumeurs hémisphériques provoquent egalement une torsion discrete lorsqu'elles sont localisées à la partie antérieure d un hemisphere La déviation est minime ou meme absente, lorsqu il y a une tumeur dans chaque hemisphere il s agit alors generalement de métastases

Les tumeurs vermiennes superieures provoquent rapidement une obstruction de l aqueduc au dessus du IVe ventricule L aqueduc dilaté est nettement refoule vers l avant, formant une coudure avec le IVe ventricule

Les tumeurs vermiennes moyennes provoquent un net refoulement de l aqueduc et du IVe ventricule vers l avant L'angle ventriculaire est pincé et la partie postérieure du IIIe est modérément soulevee

Les tumeurs vermiennes inférieures bloquent rapidement le transit liquidien causant une dilatation du IVe ventricule, qui est refoule vers l avant et qui montre l empreinte de la tumeur à convexite antérieure

Les tumeurs vermiennes ne provoquent pas ou peu de deplacement latéral

Les neurinomes de l'acoustique

Les neurinomes du VIII provoquent des deplacements variables du IVe ventricule et de l'aqueduc, suivant leurs dimensions et leur extension De face, l'aqueduc et le IVe ventricule sont tendus en arc de cercle et le IVe ventricule est tordu sur son axe a des degres variables Lorsque la tumeur s etend vers les pedoncules cérebraux, l aqueduc peut etre plus dévié que ne l'est le ventricule De profil, le IVe ventricule est soit refoulé modérément vers

l'avant, soit refoulé vers l'arrière. Le deplacement vers l'avant cause un pincement de l'angle ventriculaire et le plancher du IVe ventricule est situé en avant du point de Twining. Il sera parfois délicat de differencier les neurinomes de l'acoustique des tumeurs cerebelleuses anterieures, d'autant plus que celles-ci peuvent egalement provoquer une discrete torsion du IVe ventricule sur son axe. Le moulage tumoral nous a cependant semble plus régulier dans les cas de neurinomes. Le deplacement vers l'arriere est extremement variable et peut etre tres important.

Les meningiomes

Plus rares que les neurinomes, les meningiomes ont une symptomatologie tres polymorphe suivant leur localisation. En géneral, il n'est pas possible d'affirmer par l'iodoventriculographie seule, la nature de ces tumeurs.

Les blocages liquidiens

Les blocages apparemment complets sont généralement situes au depart de l'aqueduc ou au niveau du trou de Magendie, plus rarement a l'abouchement de l'aqueduc dans le IVe ventricule. Ces blocages sont le fait d'une tumeur, soit d'une stenose.

Des 1958, nous insistions déja sur l'absolue necessité de pratiquer dans ces cas des controles reguliers, frequents, meme pendant plusieurs heures, le patient restant en position assise. On aura souvent ainsi l'occasion de voir quand meme passer le produit opaque qui précisera soit la localisation tumorale, soit la realité d'une simple lésion stenosante.

Les obstructions post-infectieuses situees au trou de Magendie provoquent une dilatation retrograde du IVe ventricule, dont l'image est tres caracteristique: il est regulierement augmente dans toutes ses dimensions. Parfois un des recessus lateraux est plus developpe que l'autre, donnant de face un aspect asymetrique qu'il faut se garder d'interpréter trop vite comme etant le fait d'une tumeur.

Nous avons ainsi schématise l'ensemble des resultats que nous avons obtenu en cinq ans d'experience de l'iodoventriculographie dans les affections de la fosse posterieure. L'utilisation de cette méthode, qui ne doit pas etre exclusive, nous semble toutefois tres indiquee chez les patients atteints d'hypertension intracranienne ou comme complement de precision.

RÉSUMÉ

Les auteurs décrivent les techniques qu'ils utilisent pour réaliser une iodoventriculographie chez l'adulte et chez l'enfant. Ils exposent leur expérience personnelle tant dans le domaine de l'indication de l'iodoventriculographie que dans le domaine de l'interprétation des clichés. Ils passent en revue les diverses déformations ventriculaires provoquées par les lesions expansives et les lésions stenosantes de la fosse postérieure et illustrent leur exposé par des radiographies typiques des plus importantes lésions de la fosse postérieure.

SUMMARY

The authors describe the tecnique used in iodoventriculography in the adult and child and report on their experience in the interpretation of the roentgen films and indications for iodoventriculography Various ventricular deformities caused by expansive and stenosing lesions of the posterior fossa are described and illustrated in typical roentgenograms

ZUSAMMENFASSUNG

Die Autoren beschreiben die Technik der Jodventrikulographie am Erwachsenen und Kind und berichten uber ihre Erfahrungen bzgl der Deutung der Rontgenbilder und der Indikationsstellung zur Jodventrikulographie Es werden verschiedene Ventrikeldeformitaten die durch expansive und stenosierende Veranderungen der hinteren Schadelgrube verursacht wurden beschrieben und an Hand typischer Rontgenbilder illustriert

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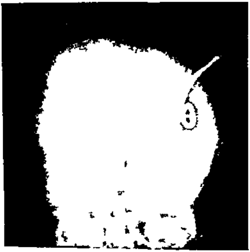


Fig 5



Fig 6



Fig 7

Fig 5 Small ventricles collapsed by marked cerebral edema which latter was caused by miliary parenchymal cerebral cysticercosis Marked sutural separation

Fig 6 Large mass originating in roof of third ventricle with encroachment on both lateral ventricles A large c t f cy t cus was removed at operation

Fig 7 Ventriculography with p t ntra t medium showing large filling d f ct n f urth ventricle A large cyst of cyst ercus was mo ed at operation

to be due to the basal arachnoiditis which impedes the free passage of air to the convexity in the same way as obstruction to the passage of the cerebrospinal fluid is produced in hydrocephalus when the obstruction process is extra ventricular i e in the tentorial notch or in the posterior fossa This may have been the reason why the findings of FILIPOV and others (2 10 11 21) i e of

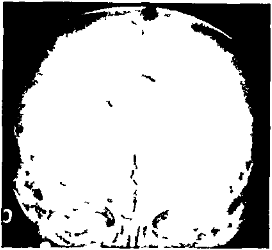


Fig 3 Parenchymal cerebral cysticercus located at left central region displacement of ventricles and non filling of subarachnoid spaces of convexity on left side



Fig 4 Large space occupying lesion in left temporal and sylvian regions produced by a cyst of cysticercus (proven at operation) Courtesy W Guzman Mexico City

graphic studies show the deformation and deviation of the ventricular system or vascular tree as in any other type of occupying lesion (Figs 3 and 4) The localization is variable but most frequently in the parenchyma of either cerebral hemisphere When there are multiple cysts, there is usually marked cerebral edema with a small, normally placed, ventricular system (Fig 5)

Ventricular cysticercosis (14 cases or 16 %) This appears as filling defects usually with rounded smooth borders, they may occur in the fourth ventricle (9 cases or two thirds of the total) (Fig 7), the third ventricle (4 cases or one third of the total) (Fig 6) or the lateral ventricle (one case) The lesion varies in size but sooner or later produces partial or complete obstruction to the flow of cerebrospinal fluid with consequent ventricular dilatation proximal to the affected area These changes are readily shown by ventriculography with a negative or positive contrast medium

Meningeal cysticercosis (49 cases or 56 %) This condition consists in the presence of basal arachnoiditis that obliterates the subarachnoid spaces especially in the posterior fossa Free or adherent cysticerci are often present The result is generalized hydrocephalus, usually communicating with the cisterna magna The pneumoencephalogram shows a dilated but not displaced ventricular system The subarachnoid spaces are usually filled only in the posterior fossa (cisterna magna, circumpeduncular) and are dilated (Fig 8) In some cases there is filling only of a dilated cisterna magna Filling of the subarachnoid spaces of the convexity, as well as of the chiasmatic and pericallosal cisterns is practically impossible to obtain in most of the cases (Fig 9) We believe this

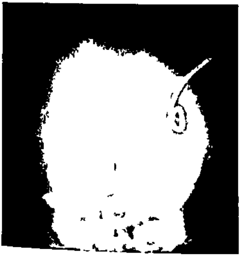


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Fig 8 Encephalography Marked dilatation of entire ventricular system and of subarachnoid cisterns around the brain stem no air on convexity or in basal cisterns Post mortem basal arachnoiditis due to cysticercosis



Fig 9 Encephalography Marked dilatation of ventricles and cisterns around the brain stem No filling of the chiasmatic cistern and the convexity Post mortem basal arachnoiditis due to cysticercosis

nodules in the pneumoencephalograms corresponding to cysts at the convexity were not confirmed It is sometimes not possible to fill the ventricles at encephalography because of obliteration of the cisterna magna In such cases we use ventriculography to show a markedly dilated ventricular system in a normal position (Fig 10)

Mixed cysticercosis (18 cases or 20 %) This type consists predominantly of meningeal lesions generally associated with cysts in the fourth ventricle or parenchymal cysts in any part of the hemispheres The roentgenologic findings are similar to those already mentioned in the meningeal forms, but in this case with evidence of parenchymal or ventricular cysts All the meningeal forms of cysticercosis constitute 76 % of the cases (56 % pure meningeal and 20 % mixed forms)

Discussion

The roentgenologic appearances in cerebral cysticercosis are not specific but must be considered in conjunction with the clinical signs and examination of the cerebrospinal fluid

The parenchymal and the ventricular forms particularly if single, offer the better prognosis (6, 20) because radical excision offers a possibility of cure The roentgenologic examination in these cases consists fundamentally of localization of the cysticercus cysts The meningeal forms have a poor prognosis opening of the posterior fossa in these cases has a high morbidity and mortality rate (6) The differential diagnosis from other space occupying lesions of the posterior fossa is therefore of great importance



Fig 10 Ventriculography Marked dilatation of the ventricles which are in normal position Post mortem basal arachnoiditis due to cysticercosis

SUMMARY

The roentgenologic findings in 88 confirmed cases of cerebral cysticercosis are reported The appearances and location of the lesions are described and the treatment and prognosis are discussed

ZUSAMMENFASSUNG

Die Rontgensymptome von 88 nachwiesenen Fallen von Cysticerkosis werden berichtet Das Aussehen und die Lokalisation der Veranderungen werden beschrieben und die Behandlung und Prognose diskutiert

RÉSUMÉ

L auteur decrit les signes radiologiques trouvés dans 88 cas de cysticercose cérébrale confirmee Il décrit l aspect et le siège des lésions et étudie le traitement et le pronostic

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ETUDE RADIOLOGIQUE DU SYNDROME DE DANDY-WALKER

par

C FAURE J LEPINTRE et G LYON

On designe sous le nom de syndrome de Dandy Walker (BENDA 1954) une variéte d hydrocephalie congenitale associee a une malformation du vermis et du toit du 4e ventricule

La coexistence d une malformation vermienne dont la description remonte a la fin du XIXe siecle (FUSARI 1891—1892 ROSSI 1891 1892) et d une hydrocephalie a eté signalee clairement pour la premiere fois par DANDY et BLACKFAN (1914) et observee depuis par de nombreux auteurs

DANDY (1921), TAGGART et WALKER (1942) ont donne de ce symptome une explication deja suggeree par MARBURG (1924) qui garde beaucoup de partisans hydrocephalie et malformation cérebelleuse seraient la consequence d une atresie ou aplasie des trous de Magendie et de Luschka et c est sous ce nom que cette hydrocephalie malformative est souvent désignee dans la litterature Cette interpretation est cependant loin d etre unanimement admise et a ete combattue recemment par BENDA (1954), DE MORSIER (1955), BRODAL et HAUGLIE HANSSEN (1959)

Depuis une quinzaine d annees, la multiplication des explorations encephalographiques et des interventions neuro-chirurgicales ont fait la preuve que le syndrome n est pas exceptionnel et BENDA va jusqu a dire qu il represente la variete la plus habituelle d hydrocephalie congenitale

n est fait ni sur la cause de la malformation vermienne, ni sur celle de l hydrocephalie

La plupart des auteurs pensent depuis TAGGART et WALKER (1942) que la malformation cérébelleuse est la consequence d une hydrocephalie foetale Cette opinion avait déja éte exprimée par MARBURG (1924) et c est notamment celle de DOW (1940) et de BRODAL et coll (1944) Pour ces auteurs, dont l autorite en matiere d anatomie du cervelet est grande l hydrocéphalie provoque par distension mécanique du toit du 4e ventricule un trouble dans le développement de la commissure cerebelleuse et un arret de la migration des elements cellulaires des ebauches vermiennes a son niveau Selon la date de debut de l hydrocéphalie, la totalite ou seulement la partie posterieure du vermis ne peut ainsi se developper

Pour d autres par contre (PINES et SURABSCHWILI 1938 CASTRILLON 1933 SAHS 1941, BENDA 1954 DE MORSIER 1955), la malformation vermienne est primitive, independante de l hydrocéphalie et appartient au groupe des dysraphies medianes rhombocéphaliques (rhomboschizis, DE MORSIER) Signalons en faveur de cette interprétation la coexistence possible d une agenesie du corps calleux

L hydrocephalie est considerée tres generalement depuis DANDY et BLACKFAN (1914) comme étant la conséquence d une absence de formation des orifices de Magendie et de Luschka

Cependant BRODAL et coll (1954) s éleve contre cette pathogénie en faisant remarquer (1) que la malformation vermienne (quelle qu en soit la cause) remonte surement a un stade foetal tres anterieur a celui auquel apparaissent les orifices de Magendie et de Luschka, (2) que chez la souris l hydrocéphalie (responsable selon lui de l anomalie cérébelleuse) existe chez le foetus bien avant la date de formation normale de ces orifices

Les travaux de WEED (1917) orientent dans le meme sens, cet auteur considere que chez le foetus avant le 4e mois le liquide cephalo-rachidien que commencent a sécreter les plexus choroides enferme dans le systeme ventriculaire determine une hydrocephalie en quelque sorte physiologique à ce stade Des lors les deux couches qui forment la membrane tectoriale du 4e ventricule vont se laisser traverser et le liquide va filtrer pour penétrer entre pie mere et arachnoide et determiner la formation des espaces sous arachnoidiens Secondairement les trous de Magendie et de Luschka vont s ouvrir et le liquide cephalo rachidien passera en plus grande quantité dans des espaces sous arachnoidiens bien développes ou il pourra circuler librement et se resorber Si au depart, le toit du 4e ventricule n est pas suffisamment perméable, le liquide cephalo rachidien est retenu dans le systeme ventriculaire le toit du 4e ventricule s etire, s adapte pour augmenter sa surface de filtration, si cette filtration reste insuffisante les espaces sous arachnoidiens ne se developpent pas Dans ce cas meme si les trous de Magendie et de Luschka s ouvrent par la suite le liquide cephalo rachidien ne pourra se

Il est interessant de signaler que des malformations analogues existent dans le regne animal et ont éte decrites chez le veau par LESBRE et FORGEOT (1905) chez le chien par BERTRAND et coll (1936), DOW (1940), chez la chèvre par VERHAERT (1942) et comme une tare genetique chez la souris par BRODAL et coll (1944), BONNEVIE et BRODAL (1946)

Ainsi, a l'heure actuelle, le syndrome de Dandy Walker n apparait plus *comme une curiosite anatomique exceptionnelle mais comme une mal* formation specifique interessant non seulement le pathologiste et l embryologiste mais egalement le clinicien, le radiologiste et le neuro chirurgien

Anatomie pathologique La malformation cérébelleuse peut intéresser tout le vermis, mais elle porte le plus souvent sur le seul lobe posterieur qui peut manquer totalement (DE MORSIER) ou etre seulement très hypoplasique chacun de ses lobules restant identifiable (GIBSON 1955, BRODAL 1945) Les hemispheres ne sont que rarement et partiellement atteints et le floculus reste toujours normal Les amygdales allongees horizontalement ne sont jamais *engagees dans le trou occipital Histologiquement l ecorce cé*rebelleuse a une structure normale et ne presente ni microgyries ni hétérotypies Le noyau dentelé est normal Les olives bulbaires peuvent etre légerement atrophiques (DE MORSIER, BRODAL) ainsi que les faisceaux spino cerebelleux (DE MORSIER)

Le toit du 4e ventricule, monstrueusement distendu, forme la paroi d un kyste qui occupe toute la fosse posterieure, ce kyste au cours de la vie foetale entrave la migration vers le bas de la tente du cervelet qui reste ainsi fixée dans sa position haute

La *membrane qui constitue cette paroi s attache en* bas sur le tronc cérébral suivant a peu pres la ligne d insertion de la toile choroidienne normale lateralement sur la face dorso mediane des hémispheres cérébelleux, alors qu en haut elle se continue avec ce qui reste du vermis dont parfois quelques languettes atrophiques s étalent sur sa face dorsale

Histologiquement elle est formee sur sa face ventriculaire par un épithélium ependymaire qui se continue avec l épendyme du 4e ventricule, et sur sa face externe par une couche conjonctive en continuite avec la pie mere qui *recouvre la face externe des hemispheres cerebelleux* Du tissu glial est parfois retrouve entre ces deux couches (MALONEY 1954, GIBSON 1955), cette membrane contient en outre des vaisseaux et des plexus choroides Les orifices de Magendie et de Luschka ne sont *habituellement pas retrouvés,* mais ceci n'est pas constant et parfois l un ou l autre de ces orifices est patent, en particulier les trous de Luschka (GIBSON, cas 2, BRODAL cas 1, CASTRILLON cas 2)

Pathogenie La pathogenie du syndrome de Dandy Walker reste obscure et il n existe actuellement aucune explication physiologique qui rende compte d une façon satisfaisante de tous ses aspects anatomiques et cliniques l accord

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etre faite a propos de la ventriculographie si l on ne soupçonne pas la malformation de Dandy Walker, les trous de trépan destinés a l injection d air peuvent etre faits au niveau habituel sur la partie posterieure de la voute et conduire non pas sur l'espace supra tentoriel, mais dans l espace sous tentoriel parfois meme le trou de trepan conduit sur le sinus latéral comme ce fut le cas dans les deux observations rapportées par MALONEY

L'encéphalographie gazeuse, dans les cas typiques, va nous montrer que l air ne peut pénetrer dans le systeme ventriculaire et confirmer simplement le caractere non communiquant de l hydrocephalie soupçonné par la clinique et quelquefois par l epreuve des colorants Dans certains cas (nos observations 1, 5 et 6, les observations 2 et 3 de SCHREIBER et REYE), une faible quantité de gaz peut penétrer dans le systeme ventriculaire, dessinant d une part des ventricules lateraux dilates et surtout montrant qu une partie du gaz injecte une fosse postérieure monstrueusement agrandie, la encore il importe par une bonne technique de bien limiter les contours de cette poche postérieure et de ne pas la confondre avec une grande citerne distendue Notons pour terminer que l encephalographie, dans quelques cas, est susceptible de révéler des malformations associees du systeme ventriculaire, en particulier une agénésie du corps calleux dont deux cas sont rapportés par SCHREIBER et REYE, et par VAN EPPS Nous memes, passant en revue nos observations du corps calleux, avons observe dans un cas une ébauche de malformation de la fosse posterieure du type Dandy Walker, nous ne rapportons pas ce cas ici en raison de l absence de vérification anatomique

Les enquetes angiographiques La premiere en date de ces explorations fut la sinusgraphie proposee par MATSON (1956) pour objectiver la position haute du torcular et des sinus lateraux chez de tout jeunes nourrissons Le contraste est injecte selon la technique habituelle dans le sinus longitudinal supérieur a travers la fontanelle Cet auteur obtient ainsi de magnifiques clichés al n que des radiographies simples n avaient pas permis de soupçonner l anomalie topographique des sinus latéraux

Personnellement nous n avons pas eu recours a cette enquete nous avons prefere l artériographie vertébrale chez deux sujets Les résultats en sont fort intéressants des le temps arteriel de l exploration, on note le trajet surelevé anormalement oblique en haut et en avant des arteres cérébrales postérieures des arteres cerebelleuses supérieures et moyennes, dans notre observation 2 fait plus remarquable encore, l analyse des clichés sériographiques de profil montre que les arteres cérébelleuses supérieures, apres 1 ou 2 centimètres de trajet, se projettent au dessus et en avant des cérébrales postérieures, objectivant ainsi la position haute de la tente du cervelet qui s'insinue entre les poles postérieurs des hémispheres cérébraux qu'elle refoule latéralement (Fig 2a) La boucle que fait la cérébelleuse inférieure autour de l amygdal cérebelleuse se trouve en position haute, largement au dessus du trou occipital



a b

Fig. 3. Cas d'hydrocéphalie d'apparition récente. A la ventriculographie les ventricules latéraux et le 3e ventricule sont dilatés. Les carrefours et le plancher du 3e ventricule sont refoulés en haut et en avant (a). Il existe une volumineuse cavité injectée par l'air dans la fosse postérieure. Le gaz est bloqué au niveau de C1 en position tête en bas (b). A noter en outre la disjonction des sutures. La position haute des gouttières des sinus latéraux.

Au temps artériolaire le contraste se répand dans les hémisphères cérébelleux petits, plaqués en avant contre la face postérieure des rochers et dans la partie postérieure des hémisphères cérébraux. Il se forme ainsi une bande opaque oblique ascendante partant de la région mastoïdienne pour se terminer vers la voûte au point d'attache anormal de la tente du cervelet. En arrière de cette bande opaque, toute la partie postéro-inférieure de la boîte crânienne reste avasculaire.

Sur les clichés de face, au temps artériolaire, les artères cérébelleuses se circonscrivent en deux zones para médianes immédiatement en arrière des rochers.

Au temps veineux enfin, on voit se dessiner la grande veine de Galien en position très surélevée, le sinus droit est presque horizontal et se termine dans le torcular dont nous avons déjà signalé la position anormale. De là partent les sinus latéraux très obliques en bas et en avant.

Cette enquête angiographique nous paraît plus riche de renseignements que la sinusographie simple.

Discussion

L'exposé précédent appelle quelques commentaires.

L'étude de nos cas personnels (observations I, 2, 3, 4, 5, 6) et des dans la littérature nous permet d'affirmer qu'il existe une entité par une dilatation du système ventriculaire prédominant sur le 4e

celui ci, monstrueusement dilate, occupe la fosse posterieure en totalité, cette entite se caracterise en outre par la position haute de la tente du cervelet et par une aplasie du vermis inferieur L impermeabilité des trous de Luschka et de Magendie est frequente, mais n'est pas constamment retrouvée La pathogenie exacte de cette malformation est mal connue, mais l examen anatomo pathologique des parois de la poche permet d exclure tout processus inflammatoire Nous ne reprendrons pas ici la discussion pathogenique Il nous parait plus interessant de situer cette anomalie par rapport aux affec tions acquises ou malformatives susceptibles de la simuler

D abord que penser des cas publies dans la litterature (COLEMAN et TROLAND 2 cas, SCHREIBER et REYE observation 4, CASTRILLON GIBSON observation 2) ou la dilatation du 4e ventricule reste moderee et ou surtout la tente du cervelet est en place normale? Ces constatations vont a l encontre du caractere malformatif foetal expose plus haut et plaideraient plutot en faveur d'un processus acquis, d autant que dans ces cas, hormis celui de SCHREIBER et REYE, il s'agit de sujets agés Faut il supposer comme COLEMAN et TROLAND (1948) qu'un equilibre s'est établi tres tot a la periode foetale entre la quantite de liquide secrété et la quantite de liquide résorbe, d ou le faible volume de la poche postérieure, n'empechant pas la migration de la tente du cervelet et des sinus lateraux? Cette explication est logique la demonstration serait toutefois plus rigoureuse si dans de tels cas une étude anatomo pathologique des parois de la poche kystique nous affirmait qu il n y a aucun stigmate d inflammation a leur niveau

Les arachnoidites de la fosse postérieure sont en effet susceptibles de créer des hydrocephalies non communicantes par obstruction acquise des trous de Magendie et de Luschka, en principe cette variete d hydrocephalie serait facile a reconnaitre, la dilatation du 4e ventricule reste modérée et, comme le soulignent DAVID et coll il existe dans ces cas une hernie occipitale des amygdales cerebelleuses qui manque toujours dans le syndrome de Dandy Walker

En fait le probleme n est pas toujours simple, nous savons que des arach noidites adhesives de la fosse posterieure peuvent creer des poches a parois minces, pellucides, sur la face postero inferieure du vermis ou postéro-interne des hemispheres cerebelleux Parfois meme ces kystes se forment au niveau des recessus lateraux du 4e ventricule avec obstruction des trous de Luschka (RUSSELL observation 39) L aspect devient alors tres voisin de celui du syndrome de Dandy-Walker, mais dans tous ces cas, le contexte clinique, l anamnèse l aspect radiologique montrant une tente du cervelet en place normale et l examen histologique des membranes confirment la nature acquise, inflammatoire de l affection

Un dernier point souleve une discussion plus difficile Plusieurs publications (ZEHNDER, ROBERTSON, GARDNER et coll) rapportent des observations de kystes arachnoidiens congenitaux non inflammatoires a double paroi développés au

voisinage ou meme dans le toit du 4e ventricule et s accompagnant parfois (ROBERTSON) d anomalies de la tente du cervelet Nous memes avons observe 2 cas analogues (observations 7 et 8) Comme le mentionne ROBERTSON pour son cas, et c est egalement vrai pour les notres, si la paroi profonde du kyste s etait rompue rien ne differencierait plus alors ces observations de la malformation de Dandy Walker telle que nous l avons decrite On a ici l impression que la poche liquidienne, au lieu de se faire dans le 4e ventricule, s est developpee dans un espace représente par le clivage du toit ventriculaire GARDNER et coll, reprenant la théorie de WEED exposée plus haut, pense que la perméabilite de la membrane profonde du toit du 4e ventricule etant plus grande que celle de la membrane superficielle il peut se former une poche clivant ainsi la membrane tectoriale entre ependyme et pie mere, ceci leur permet d'assimiler cette variete de kyste a la malformation de Dandy Walker vraie Pour notre part constatant dans nos observations 7 et 8 l anomalie associee du vermis inferieur, la position haute de la tente du cervelet et dans un cas (observation 7) la presence de tissu glial dans la membrane nous sommes enclins a assimiler ces kystes a la malformation de Dandy Walker Signalons toutefois que selon RUSSELL la presence d eléments gliaux dans les parois d un kyste arachnoidien ne prouve pas sa nature congénitale elle a observe des ilots gliaux dans des arachnoidites post meningétiques authentiques

GARDNER et coll reprenant la theorie pathogenique de WEED, trouveraient au depart une explication commune a la malformation d Arnold Chiari et au syndrome de Dandy Walker et pensent qu'il peut y avoir des formes intermediaires entre les deux affections Bien que cette opinion soit partagee par WALKER, nous ne les suivrons pas sur ce terrain

De meme nous pensons que s il existe parfois des similitudes entre certaines meningo encephaloceles occipitales et le syndrome de Dandy Walker, il y a lieu de differencier nettement ces deux entites

RÉSUMÉ

La malformation de Dandy Walker n est pas une rareté Il importe que neurologues neuro-chirurgiens et radiologistes sachent la reconnaitre et ne pas considérer qu il s agit là d hydrocéphalies au-des us de toute ressource chirurgicale Notre matériel et l étude des cas publiés dans la littérature nous permettent d affirmer que reconnue tot et convenablement traitée cette malformation peut guerir dans un pourcentage appréciable de cas

SUMMARY

The malformation called the Dandy Walker syndrome is not a rare one and it is important that it should be recognized as such by neurologists neurosurgeons and radiologists It should not be regarded as a kind of hydrocephaly not treatable We have found from our material as well as from a study of cases reported in the literature that being recognized at an early stage and treated appropriately this deformation may regress in an appreciable percentage of cases

celui ci, monstrueusement dilate, occupe la fosse posterieure en totalité cette entité se caracterise en outre par la position haute de la tente du cervelet et par une aplasie du vermis inférieur L'impermeabilite des trous de Luschka et de Magendie est frequente, mais n'est pas constamment retrouvée La pathogénie exacte de cette malformation est mal connue, mais l examen anatomo pathologique des parois de la poche permet d'exclure tout processus inflammatoire Nous ne reprendrons pas ici la discussion pathogénique Il nous parait plus interessant de situer cette anomalie par rapport aux affections acquises ou malformatives susceptibles de la simuler

D abord que penser des cas publies dans la littérature (Coleman et Troland 2 cas, Schreiber et Reye observation 4 Castrillon Gibson observation 2) ou la dilatation du 4e ventricule reste modérée et ou surtout la tente du cervelet est en place normale? Ces constatations vont a l encontre du caractere malformatif foetal exposé plus haut et plaideraient plutot en faveur d un processus acquis, d'autant que dans ces cas, hormis celui de Schreiber et Reye, il s agit de sujets ages Faut il supposer comme Coleman et Troland (1948) qu un equilibre s'est etabli tres tot a la periode foetale entre la quantite de liquide secreté et la quantite de liquide resorbé, d ou le faible volume de la poche posterieure, n empechant pas la migration de la tente du cervelet et des sinus lateraux? Cette explication est logique, la demonstration serait toutefois plus rigoureuse si dans de tels cas une étude anatomo pathologique des parois de la poche kystique nous affirmait qu il n y a aucun stigmate d inflammation a leur niveau

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Un dernier point souleve une discussion plus difficile Plusieurs publications (Zehnder, Robertson, Gardner et coll) rapportent des observations de kystes arachnoidiens congenitaux non inflammatoires à double paroi developpés au

voisinage ou même dans le toit du 4e ventricule et s'accompagnant parfois (ROBERTSON) d'anomalies de la tente du cervelet. Nous mêmes avons observé 2 cas analogues (observations 7 et 8). Comme le mentionne ROBERTSON pour son cas, et c'est également vrai pour les nôtres, si la paroi profonde du kyste s'était rompue rien ne différencierait plus alors ces observations de la malformation de Dandy Walker, telle que nous l'avons décrite. On a ici l'impression que la poche liquidienne, au lieu de se faire dans le 4e ventricule, s'est développée dans un espace représenté par le clivage du toit ventriculaire. GARDNER et coll., reprenant la théorie de WEED exposée plus haut, pense que la perméabilité de la membrane profonde du toit du 4e ventricule étant plus grande que celle de la membrane superficielle, il peut se former une poche clivant ainsi la membrane tectoriale entre épendyme et pie mère; ceci leur permet d'assimiler cette variété de kyste à la malformation de Dandy-Walker vraie. Pour notre part, constatant dans nos observations 7 et 8 l'anomalie associée du vermis inférieur, la position haute de la tente du cervelet et dans un cas (observation 7) la présence de tissu glial dans la membrane, nous sommes enclins à assimiler ces kystes à la malformation de Dandy-Walker. Signalons toutefois que selon RUSSELL, la présence d'éléments gliaux dans les parois d'un kyste arachnoïdien ne prouve pas sa nature congénitale; elle a observé des îlots gliaux dans des arachnoïdites post méningétiques authentiques.

GARDNER et coll., reprenant la théorie pathogénique de WEED, trouveraient au départ une explication commune à la malformation d'Arnold Chiari et au syndrome de Dandy-Walker et pensent qu'il peut y avoir des formes intermédiaires entre les deux affections. Bien que cette opinion soit partagée par WALKER, nous ne les suivons pas sur ce terrain.

De même nous pensons que s'il existe parfois des similitudes entre certaines méningo-encéphalocèles occipitales et le syndrome de Dandy Walker, il y a lieu de différencier nettement ces deux entités.

RÉSUMÉ

La malformation de Dandy Walker n'est pas une rareté. Il importe que neurologues, neuro-chirurgiens et radiologistes sachent la reconnaître et ne pas considérer qu'il s'agit là d'hydrocéphalies au-dessus de toute ressource chirurgicale. Notre matériel et l'étude des cas publiés dans la littérature nous permettent d'affirmer que reconnue tôt et convenablement traitée, cette malformation peut guérir dans un pourcentage appréciable de cas.

SUMMARY

The malformation called the Dandy Walker syndrome is not a rare one and it is important that it should be recognized as such by neurologists, neurosurgeons and radiologists. It should not be regarded as a kind of hydrocephalus not treatable. We have found, from our [illegible] as well as from a study of cases reported in the literature, that being recognized at an [illegible] stage and treated appropriately this deformation may regress in an appreciable per[illegible] cases.

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ZUSAMMENFASSUNG

Die Missbildung bekannt unter dem Namen Dandy Walkersyndrom ist nicht selten. Es ist wichtig dass man ihr von neurologischer neurochirurgischer und radiologischer Seite entsprechende Aufmerksamkeit schenkt Sie sollte nicht als eine Art Hydrocephalus der nicht behandelt werden kann aufgefasst werden Auf Grund unseres eigenen Materials und Literaturstudien ziehen wir den Schluss dass sich diese Missbildung bei frühzeitiger Diagnose und Behandlung in einem beachtenswerten Prozentsatz zurückbilden kann

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POSITIVE CONTRAST VENTRICULOGRAPHY OF PINEAL REGION TUMOURS

by

BRYAN JENNETT, RICHARD JOHNSON, and REGINALD REID

The diagnosis of tumours in the pineal region rests largely on the radiologic appearances No longer is there believed to be a pathognomonic clinical syndrome, and pathologic verification in life is rare Yet the delineation of the posterior part of the 3rd ventricle by air studies in these particular cases presents a number of difficulties which the positive contrast method is especially useful in surmounting

For many years after KRABBE (1923) coined the term pinealoma discussions were dominated by arguments about the histologic appearances Most pathologi reports were based on post mortem material and reflected the more malignant types of tumour because the surgical hazards of approaching this region made it unusual for biopsies to be taken in life However surgeons have long known that some cases of pineal region tumour have a remission of symptoms and survive many years following short circuiting operations and radiotherapy two such cases have recently been verified by PENNYBACKER (1961) as ependymomas of the quadrigeminal plate

Many case reports have accumulated over the years and they have been collected from time to time The largest series are those of HALDEMAN (1 BING GLOBUS & SIMON (1938) and RINGERTZ NORDENSTAM & FLYGER (amounting in aggregate to 237 tumours in this region Only about a could be recognised as having arisen in adult pineal tissue, these v

greatly in character, justifying a variety of labels pinealoma, pinealocytoma pinealoblastoma, and carcinoma A further sixth (of 237) were regarded as teratomas, but some pathologists (RUSSELL & RUBINSTEIN 1959) believe that many more of the tumours regarded as developing from adult pineal cells are in fact teratomatous and do not necessarily arise either in the pineal body or in ectopic pineal tissue Gliomas of various kinds made up a fifth of the series mentioned, and also figure prominently in the large number of tumours in this region reviewed by ZULCH (1957) Numerous other tumours have been reported, such as sarcoma, tuberculoma, lipoma, a variety of cysts (some neoplastic and some almost certainly herniations of the lateral or third ventricle), and arterio venous malformations including aneurysms and varices of veins of Galen It is perhaps sufficient to conclude that tumours in this region are of great variety, some, probably the majority, having arisen outside the pineal body itself, it would be surprising if they presented a consistent clinical or radiologic pattern

Clinical The peculiar clinical syndromes associated with pineal tumours were first described by BAILEY & JELLIFFE (1911) and subsequently confirmed by HORRAX & BAILEY (1925, 1928) The characteristic disorders of ocular movement and pupillary reaction consist of (1) loss of conjugate upward movement and of convergence (attempts to execute these movements may induce nystagmoid jerks, but sustained nystagmus of conventional cerebellar or brain stem pattern may also occur) and (2) pupils reacting poorly to light, though the reaction to accommodation is often preserved inequality of the pupils is common, but the widely dilated pupils originally reported are rare even in advanced cases Parinaud's syndrome (PARINAUD 1883) is the term sometimes applied to loss of upward movement and convergence, but it is seldom seen in a pure form with these tumours

Although these characteristic disorders are stressed in many reports of pineal tumours, a careful study of several clinical series (HORRAX & BAILEY 1925, BAGGENSTOSS & LOVE 1939, POSNER & HORRAX 1946, RAND & LEMMEN 1953 — an aggregate of 70 cases) shows that less than half the patients had loss of upward gaze and less than half had pupillary abnormality Moreover POSNER & HORRAX pointed out that limited upward movement of the eyes could occur with acoustic neuromas and with tumours of the cerebral hemisphere, and indeed it had previously been reported in pontine tuberculomas. More recently one of us (JOHNSON 1957) had demonstrated that loss of upward movement of the eyes almost certainly results from bilateral compression of the dorsal mid brain, and is a common sequel of an expanding lesion either above or below the tentorium, *which causes tentorial herniation*

Pubertas praecox is the other feature stressed in early papers as characteristic of tumours in this region, it is strangely confined to prepubertal male children BING and his associates (1938) discovered that only about a third of 56 boys

under fifteen with pineal region tumours had this feature, and in most of these cases the tumour had spread beyond or arisen outside the pineal region in fact 71 % had clinical signs of hypothalamic involvement WEINBERGER & GRANT (1941) reported 16 cases of pubertas praecox with a normal pineal gland, and concluded that the lesion was usually in the posterior hypothalamus It is now generally recognised that this condition may result from involvement of the tuberal region by any pathologic process and is not attributable to abnormal secretion from teratomatous cells in pineal tumours

Radiographic features Conventional films will often show evidence of long standing raised pressure due to the internal hydrocephalus to which these tumours invariably give rise The sella may be enlarged and the posterior clinoids eroded from contact with the dilated anterior end of the third ventricle Pineal calcification in children and young adults is probably commoner when there is a tumour in this region but neither its presence nor its type is diagnostic however its relation to the posterior part of the third ventricle and to the aqueduct as demonstrated by contrast media may clearly indicate that there is a mass in this situation Scattered calcification throughout a pineal tumour (TWINING 1939) is rarely seen

The largest series of pineal region tumours with a detailed account of the radiologic features is that of RAND & LEMMEN (1953) who had 32 cases Skull changes of raised pressure occurred in 60 % and rather less than half the cases had pineal calcification Constant features on ventriculography were aqueduct block and a filling defect in the posterior part of the 3rd ventricle, this was smooth in 22 and irregular in 5 In more than half the cases it occupied a half or more of the antero posterior length of the ventricle and in 3 came far enough forward to partially block the foramen of Monro In 7 cases there was in addition a filling defect in the lateral ventricle, it is clear that this review included tumours that extended well beyond the pineal region

Although air ventriculography will frequently demonstrate a typical filling defect in the posterior part of the 3rd ventricle as well as giving valuable information about the size of the lateral ventricles it does not always do so, indeed TWINING (1939) referred to the difficulty of clearly demonstrating this region in some cases The dilated lateral ventricles, which fill first when air is introduced by this route, overlie the back end of the 3rd ventricle which, when it is compressed and deformed may be difficult to see Consequently it may prove impossible to see this important area with any degree of certainty or in any detail Two manoeuvres have been suggested to improve visibility of the third ventricle in these circumstances One is autotomography (ZIEDSES DES PLANTES 1950) in which the head is rotated about its long axis so that the lateral ventricles are blurred in relation to the central 3rd ventricle The other is replacement of the air in the lateral ventricles by fluid once the 3rd ventricle has been filled with air (VERBIEST 1950) In addition conventional tomography

greatly in character, justifying a variety of labels pinealoma, pinealocytoma pinealoblastoma, and carcinoma A further sixth (of 237) were regarded as teratomas, but some pathologists (RUSSELL & RUBINSTEIN 1959) believe that many more of the tumours regarded as developing from adult pineal cells are in fact teratomatous and do not necessarily arise either in the pineal body or in ectopic pineal tissue Gliomas of various kinds made up a fifth of the series mentioned, and also figure prominently in the large number of tumours in this region reviewed by ZULCH (1957) Numerous other tumours have been reported, such as sarcoma, tuberculoma, lipoma a variety of cysts (some neoplastic and some almost certainly herniations of the lateral or third ventricle), and arterio venous malformations including aneurysms and varices of veins of Galen It is perhaps sufficient to conclude that tumours in this region are of great variety, some probably the majority, having arisen outside the pineal body itself, it would be surprising if they presented a consistent clinical or radiologic pattern

Clinical The peculiar clinical syndromes associated with pineal tumours were first described by BAILEY & JELLIFFE (1911) and subsequently confirmed by HORRAX & BAILEY (1925, 1928) The characteristic disorders of ocular movement and pupillary reaction consist of (1) loss of conjugate upward movement and of convergence (attempts to execute these movements may induce nystagmoid jerks, but sustained nystagmus of conventional cerebellar or brain stem pattern may also occur) and (2) pupils reacting poorly to light, though the reaction to accommodation is often preserved inequality of the pupils is common, but the widely dilated pupils originally reported are rare even in advanced cases Parinaud s syndrome (PARINAUD 1883) is the term sometimes applied to loss of upward movement and convergence but it is seldom seen in a pure form with these tumours

Although these characteristic disorders are stressed in many reports of pineal tumours a careful study of several clinical series (HORRAX & BAILEY 1925 BAGGENSTOSS & LOVE 1939, POSNER & HORRAX 1946, RAND & LEMMEN 1953 — an aggregate of 70 cases) shows that less than half the patients had loss of upward gaze and less than half had pupillary abnormality Moreover POSNER & HORRAX pointed out that limited upward movement of the eyes could occur with acoustic neuromas and with tumours of the cerebral hemisphere, and indeed it had previously been reported in pontine tuberculomas More recently one of us (JOHNSON 1957) had demonstrated that loss of upward movement of the eyes almost certainly results from bilateral compression of the dorsal mid brain, and is a common sequel of an expanding lesion either above or below the tentorium, which causes tentorial herniation

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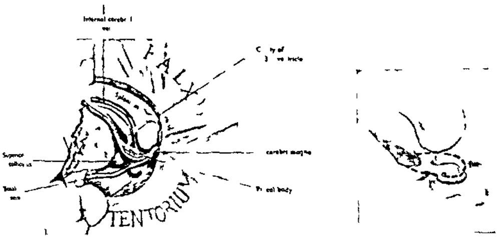


Fig 2 Dissection of the pineal region the internal cerebral veins skirt the base of the suprapineal recess. The immediate relationships of the pineal body are shown in the small combined sketch to the right the usual position of the suprapineal recess being indicated by the interrupted line

could explore them directly, and some might be totally excised, although various short circuiting operations have proved their worth in certain cases over the years This study has been made in an attempt to determine whether there were any recognisable patterns of deformity which might indicate the pathologic nature of these tumours

Anatomy The posterior end of the 3rd ventricle abuts on the large subarachnoid space of the cisterna venae magnae cerebri (Fig 2) This cistern is bounded above by the splenium of the corpus callosum, below by the quadrigeminal plate behind by the posterior edge of the incisura tentorii and the upper surfaces of the cerebellar hemispheres and the vermis which rise above the free edge of the tentorium for a short distance and laterally by the diverging pulvinar eminences The pineal body projects into this space and lies isolated apart from the suprapineal recess of the 3rd ventricle and the membranes of the tela choroidea which carry the internal cerebral veins as they skirt the base of the suprapineal recess on their way to the great cerebral vein, which runs up behind the splenium to join the straight sinus (JOHANSON 1953) It is very understandable that tumours of the pineal which are free to grow to a considerable size, should be expected to produce a sharply defined clinical syndrome as they begin to compress or invade structures in the quadrigeminal plate However, tumours arising in the 3rd ventricle, in the corpus callosum, and in the thalamus or tumours growing through these structures, can silently reach this space, as may tumours extending upwards from the cerebellar hemispheres or from the vermis The internal surface of the back end of the 3rd ventricle



a b

Fig 1 a) Air ventriculogram Marked hydrocephalus of lateral ventricles and anterior end of 3rd ventricle no air in posterior part of 3rd ventricle Interpreted (elsewhere) as indicating a pineal tumour b) Myodil ventriculogram Complete aqueduct block (after 24 hours) No filling defect of 3rd ventricle Undisplaced pineal calcification

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Apart from this technical difficulty there is the danger of air replacement in the presence of severely raised intracranial pressure with the risk of change pressures causing minor movements when vital midbrain structures are already critically deformed Moreover the recommendation that lumbar air encephalography is safe in the presence of papilloedema has not helped in the elucidation of tumours in this situation because an aqueduct block so often exists that it is rarely possible to fill the 3rd ventricle from below, although some information may be gleaned from filling of the cisterns

Present study

The radiologic interpretation of lesions in this part of the brain is of first importance surgically Modern anaesthesia with controlled respiration and blood pressure has made the approach to this region much safer and, if relatively benign or circumscribed tumours could be recognised surgeons



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Fig 6 Patent suprapineal recess with pinealoma (proven at autopsy)



Fig 7 Marked downward and forward displacement of obstructed iter due to tectal plate tumour causing posterior 3rd ventricle filling defect

effects Moreover there is no need for urgent surgery because the replacement of 1 5 ml of cerebrospinal fluid with oil does not appear to upset the intracranial dynamics even when the pressure is very high Because of this the examination may be continued for many hours even on to a second day and as a result parts of the ventricular system may be filled which would otherwise not be shown up at all

Myodil is introduced through a right frontal burr hole which is made either immediately before the radiologic examination or some days previously, in children this is sometimes done under general anaesthesia and ventriculography performed later without anaesthesia The contrast medium is injected into the frontal horn through a brain cannula with the patient sitting up and manipulated into the 3rd ventricle A small bubble of air is injected with the Myodil, this carries a tiny meniscus of Myodil with it to the uppermost part of the lateral ventricle, which serves both to indicate the size of the ventricle and the position in which any film was taken

Results

Among some 450 Myodil ventriculographies performed in this department over the last ten years there have been 29 with filling defects in the posterior 3rd ventricle the criterion for inclusion as a pineal region tumour More than half of the 15 cases which were pathologically verified were gliomas of some type whilst there were only two pinealomas A quarter of the cases were under



Fig 9 Case of vermis astrocytoma Upper left Stretching of iter and posterior 3rd ventricle displacement of iter and 4th ventricle Upper right Notching of suprapineal recess by posterior segment of internal cerebral veins Lower left Normal venogram great cerebral vein curved downwards Lower right Elevation of great cerebral vein and posterior segment of internal cerebral vein

Aqueduct block, radiologically speaking is a relative term which depends on how persistent an examination is made With air studies it is quite common to find no air passing through the iter even if small amounts do so it is unlikely that air will be seen either in the iter or in the 4th ventricle With Myodil every drop can be seen and even after three consecutive films had shown a complete hold up in the upper part of the iter or at the exit from the third ventricle it was quite common for the oil to begin to trickle through often giving pretty pictures of the narrowed and deformed aqueduct Because of this it has become our routine when a complete iter block is shown on the initial films, to leave the patient in the supine position so that the contrast



a b

Fig 10 a) Upward bowing of anterior part of internal cerebral vein due to pineal region tumour spreading well forward in 3rd ventricle calcified pineal b) Irregular filling defect and greatly stretched posterior ventricle wall

medium can leave the 3rd ventricle through the iter, films are repeated over several hours, or even the next day, if the block persists There were 12 cases in which no Myodil passed through the aqueduct, all but one had at least three films taken the last of which showed the block still complete There were 8 cases in which Myodil still completely blocked on the third film eventually passed into the aqueduct and 4th ventricle All but two of the 29 cases had some degree of iter obstruction

Forward displacement of the iter, in relation to the Stockholm line (SAHLSTEDT 1935) was discovered in 21 of the 29 cases Normally the origin of the aqueduct lies about the junction of the lower and middle thirds of this line which runs from the posterior clinoid process through this point to the skull wall in 14 cases the aqueduct lay more than 10 mm ventral to this point

3rd ventricle abnormalities consisted of deformity of the posterior wall two types being distinguished — those which were relatively smooth and those which were irregular Lateral displacement of the 3rd ventricle in the axial views was unusual, occurring only in three cases

There were 17 cases with a mainly smooth ventricular defect, which usually appeared crescentic, convex forwards, as though the smooth anterior edge of a tumour was abutting on to and stretching the ventricular wall (Fig 3 Sometimes the convexity was double, the smooth curve interrupted by a



Fig 11 Nodular filling defect in 3rd ventricle (pinealoma)



Fig 12 Irregular filling defect of 3rd ventricle with modelling of Myodil in the lateral and a p views (glioblastoma

backward projection this may be the pseudopineal recess mentioned by some authors (see Fig 4) In many of these cases the height of the posterior ventricular wall was greatly increased this seems to be the result of direct stretching by the tumour in the neighbourhood and not simply of ventricular dilatation consequent on aqueduct obstruction, because such an appearance was unusual in cases of gross hydrocephalus due to simple iter stricture

In a number of cases the suprapineal recess was obliterated and the filling defect formed the arc of a circle the centre of which was the site of pineal calcification and the gap between the posterior ventricular wall and this calcification suggested intervening tumour In one patient in whom Myodil ventriculography was repeated, because of recurrence of symptoms after three years this gap had widened considerably demonstrating further tumour growth in spite of roentgen therapy (Fig 5)

The suprapineal recess was not always obliterated although most radiologic textbooks regard this as the cardinal sign of a pineal tumour In one of the cases with a proven pinealoma there was a well developed suprapineal recess (Fig 6) which cannot be taken to exclude a tumour of this kind However it is possible for such a tumour to originate from sites remote from the pineal body as emphasized by RUSSELL (1954) RAND & LEMMEN (1953) refer specifically to a pinealoma arising from the posterior wall of the 3rd ventricle below the aqueduct

In some cases the defect in the 3rd ventricle was less striking than the downward and forward displacement of the iter which was also narrowed and obstructed (Fig 7) Such an appearance may be produced by the upward growth of a vermis tumour, as TWINING (1939) observed If the 4th ventricle can be demonstrated the true state of affairs will usually be appreciated This was so in two cases, the first a child of six with a vermis astrocytoma (Fig 8) after five consecutive films had displayed a blocked aqueduct the 4th ventricle



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RÉSUMÉ

La ventriculographie au Myodil permet d étudier avec exactitude de façon détaillée et sans danger les divers types de déformation de la partie postérieure du troisieme ventricule que causent les tumeurs de la région pinéale La mise en évidence d un blocage partiel de l aqueduc et du quatrieme ventricule peut etre tres utile pour distinguer ces tumeurs des lésions de la fosse postérieure B aucoup de ces tumeurs ont probablement leur origine en dehors de la pineale et la plupart sont malignes *Excepté les diverticules tumoraux qui sont toujours un* signe de malignite il n y a pas de relation constante entre le type d image lacunaire et la nature de la tumeur

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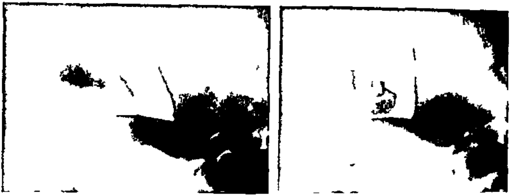
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Fig 15 a) Filling defect of 3rd ventricle suggestion of pseudo-recess b) Pseudo-recess has developed into a tumour diverticulum and Myodil has leaked out through the fistula into the cistern

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We wish to acknowledge the continued cooperation of Mr Eric Mercer and Miss Sylvia Smith successively superintendent radiographers and the assistance of the various neurosurgical colleagues who have shared with us the performance of these investigations the Department of Medical Illustration for reproducing the roentgenograms and Miss Davison and Mr Neave for the drawings

SUMMARY

Myodil ventriculography enables the various types of deformity of the posterior wall of the 3rd ventricle which occur with tumours in the pineal region to be studied accurately safely and in detail Demonstration of the partially blocked aqueduct and 4th ventricle may be invaluable in distinguishing these tumours from posterior fossa lesions Many of these tumours probably arise outside the pineal body and most are malignant Apart from tumour diverticuli which always indicated malignancy there was no constant correlation between the type of filling defect and the nature of the tumour

ZUSAMMENFASSUNG

Myodil Ventrikulographie ermoglicht ein exaktes sicheres und detailliertes Studium von verschiedenen Typen von Deformitaten der hinteren Wand des 3 Ventrikels wie sie bei Tumoren der pinealen Region vorkommen Die Darstellung des partiell blockierten Aquadukts und 4 Ventrikel kann in der Differenzialdiagnose dieser Tumoren von Veranderungen der hinteren Schadelgrube von unschatzbarem Wert sein Viele dieser Tumoren haben ihren Ursprung wahrscheinlich ausserhalb des corpus pineale und die meisten sind malign Abgesehen von Tumordivertikeln die immer bosartig sind fand man niemals eine konstante Beziehung zwischen der Art des Fullungsdefektes und der Natur des Tumors

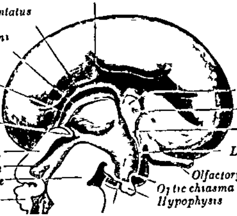


Fig 1 Mid sagittal section of the brain at the fourth month of development showing the primitive anterior commissure and corpus callosum The stippled area represents the area from which the septum pellucidum will come (From GRAY'S Anatomy)

Maximum a p length of septum pellucidum
Vertical height of septum pellucidum measured from the posterior lip of the foramen of Monro
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1A — Distance between the inferior surface of the genu of the corpus callosum and the inferior surface of the frontal lobe
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2 — Minimum distance between the top of the brain and the superior surface of the corpus callosum at its highest point this distance was measured at right angles to the plane of the base of the brain and for this plane we took a line joining the lowest points of the frontal and occipital lobes
3 — Distance from the superior surface of the parietal lobe to the posterior part of the body of the corpus callosum at a point where a depression in the corpus callosum is usually seen
4A — Minimum distance from the postero superior surface of the splenium of the corpus callosum to the postero superior surface of the brain
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Since the inferior surface of the temporal lobe projects downwards in different degrees in different patients we took the line joining the inferior surfaces of the frontal and occipital lobes to represent the plane of the base of the brain This plane corresponds to a line joining the nasofrontal suture to the internal occipital protuberance on skull roentgenograms

VARIATIONS IN CORPUS CALLOSUM, SEPTUM PELLUCIDUM AND FORNIX, AND THEIR EFFECT ON THE ENCEPHALOGRAM AND CEREBRAL ANGIOGRAM

by

DONALD L. MCRAE and GUIDO CASTORINA

The midline areas of the body are common sites of congenital abnormalities and anatomical variations. The corpus callosum, the septum pellucidum and the fornices are more or less midline structures. They develop from a midline structure, the primitive anterior commissure (Fig. 1). We wish to call attention to some anatomical variations of these structures which may be of some interest to radiologists. The points we wish to discuss are variations in the shape and size of the corpus callosum and septum pellucidum, variations in the relation of the posterior parts of the corpus callosum and fornix, and variations in the size of the cistern of the velum interpositum and the position of the roof of the velum interpositum and the position of the roof of the 3rd ventricle. A few comments will be made on variations in the veins of the septum pellucidum and the internal cerebral veins as well as variations in the position of the anterior cerebral and supracallosal arteries.

Method. The brains studied came from patients whose death was caused by non-neurological disease, except for one brain which was used for coronal sections but not for measurements. The brains had been fixed in isotonic formalin and had been suspended in the formalin by means of strings tied to the carotid arteries in order to prevent flattening of the top of the brain. Thirty-seven brains were sectioned in or close to the mid sagittal plane. Others were sectioned coronally to better show the relationships of the structures being studied. An effort was made to section the brains slightly to one side of the midsagittal plane in order to preserve the septum pellucidum. The arrangement of the arteries and veins on the mesial surface of the section that contained the septum pellucidum was recorded and various measurements of the midline structures were made as follows (see Fig. 2).

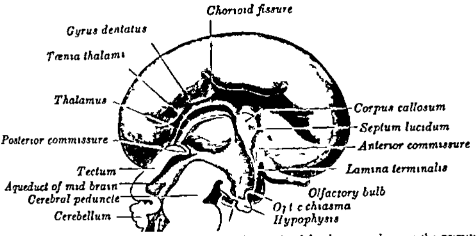


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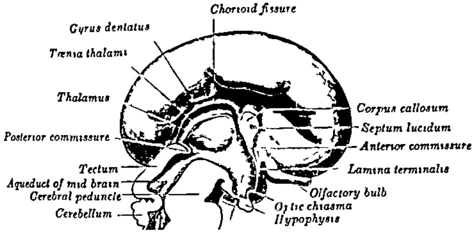


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- 1B — Distance between the anterior extremity of the brain and the corpus callosum
- 1C — Distance between the antero-superior surface of the genu of the corpus callosum and the closest part of the antero-superior surface of the brain
- 2 — Minimum distance between the top of the brain and the superior surface of the corpus callosum at its highest point this distance was measured at right angles to the plane of the base of the brain and for this plane we took a line joining the lowest points of the frontal and occipital lobes
- 3 — Distance from the superior surface of the parietal lobe to the posterior part of the body of the corpus callosum at a point where a depression in the corpus callosum is usually seen
- 4A — Minimum distance from the postero-superior surface of the splenium of the corpus callosum to the postero-superior surface of the brain
- 4B — Distance from the posterior edge of the splenium to the plane of the occipital pole of the brain
- 4C — Distance from the splenium to the plane of the base of the brain (actually the splenium is level with the inferior surface of the brain at the junction of the occipital and temporal lobes on the lower mesial edge of the brain but this point is higher than the line we used to indicate the base of the brain)

Since the inferior surface of the temporal lobe projects downwards in different degrees in different patients, we took the line joining the inferior surfaces of the frontal and occipital lobes to represent the plane of the base of the brain This plane corresponds to a line joining the nasofrontal suture to the internal occipital protuberance on skull roentgenograms

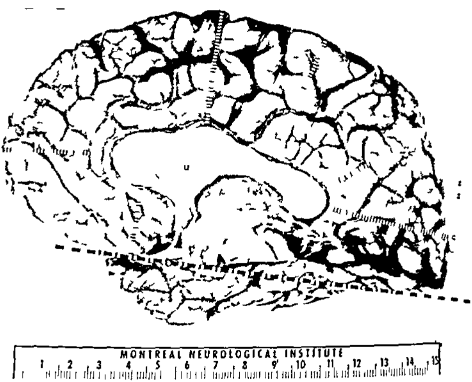


Fig. 2. Mid sagittal section to show some of the measurements made. This specimen shows a thick corpus callosum of average length with two depressions on its superior surface of common size and shape. Septum pellucidum is about average in length; cistern of velum interpositum is about average in size and shape. The pericallosal artery is unusually far anterior to the lamina terminalis.

Results

The distances from the external surface of the corpus callosum to the nearest edge of the mesial surface of the adult brain are given in Table 1. These distances indicate the amount of cortex on the mesial surface of the brain. The corpus callosum is not parallel to the edge of the brain. It is closer an

Table I

Distance in millimeters from corpus callosum to edge of brain

	Maximum	Minimum	Mean
1A	30	20	24
1B	40	30	35
1C	41	31	35
2	48	33	40
3	53	40	44
4A	54	38	46
4B	64	49	56
4C	28	15	20



Fig 3 Mid sagittal section of a brain with marked thinning of posterior part of body of corpus callosum at the posterior depression

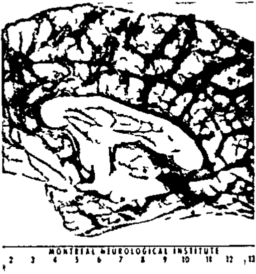


Fig 4 Mid sagittal section of a brain with a long septum pellucidum and a thin corpus callosum In this case the ventricles were not enlarged

teriorly than posteriorly The body of the corpus callosum dips progressively downwards as it passes posteriorly

The mean distance from the inferior surface of the genu of the corpus callosum to the inferior edge of the frontal lobe was 24 mm (range 20 mm to 30 mm) The mean distances from the anterior and the antero superior surfaces of the genu to the corresponding edges of the mesial surface of the brain were equal namely 35 mm The greatest difference between these two measurements in any one specimen was 4 mm

The means of measurements (2) (3) (4A) and (4B) progressively increase Measurement (2) was never less than measurement (3) and they were equal in only one specimen The greatest intra individual variation was 10 mm but it occurred only once Measurement (3) was smaller than measurement (4 A) in sixteen cases greater in eight and equal in the remainder The greatest intra individual variations were 5 mm and 4 mm — three less than (4A) and three greater than (4A) Measurement (4A) was always less than (4B) the greatest variation in any one specimen being 14 mm

This large intra individual variation in the posterior relationship of the corpus callosum and the brain edge is partly due to the frequent presence of a depression on the superior surface of the posterior part of the body of the corpus callosum (Figs 2 and 3) This depression usually indicates a thin area in the corpus callosum (Fig 3) There is sometimes another depression in the anterior part of the body of the corpus callosum but it is usually smaller (Figs 2 and 3) The superior surface of the corpus callosum was a continuous



Fig 5 Coronal section through middle of 3rd ventricle of brain with short septum pellucidum, separation of portions 3 of lateral ventricles by the fused corpus callosum and fornix

smooth curve in only 11 of 37 cases or 30 % In six cases a posterior depression was present alone, in two cases an anterior depression was present alone and in 18 cases, or 50 %, both anterior and posterior depressions were present

The variations in Table 1 are partly due to differences in size of the brains Therefore the absolute figures in millimeters are not as useful as ratios or indices that can be expressed in percentages and used in individual cases An attempt was made to find a useful index of the height of the anterior and posterior parts of the corpus callosum since they are often outlined with gas at encephalography In addition the genu and the splenium of the corpus callosum are usually in close relation to the supra callosal artery and the posterior parts of the internal cerebral veins respectively The superior surface of the genu of the corpus callosum is approximately halfway between the inferior and superior surfaces of the frontal lobe when these distances are measured at right angles to the base of the brain It is usually slightly farther from the base than from the top (mean 53 % range 46 % to 58 %) The inferior surface of the splenium is closer to the base of the brain than it is to the superior surface (mean 24 %, range 19 % to 31 %)

The a p length of the corpus callosum does not bear a constant relationship to the a p length of the brain (Table 2) The adult corpus callosum is

Table 2

Lengths in millimeters of septum pellucidum corpus callosum and brain

	Maximum	Minimum	Mean
Length of septum pellucidum	[illegible]	26	[illegible]
Length of corpus callosum	80	68	[illegible]
Length of brain	181	14[illegible]	[illegible]
Ratio of septum pellucidum to corpus callosum	69	30 %	51
Ratio of corpus callosum to brain	50 %	39	41

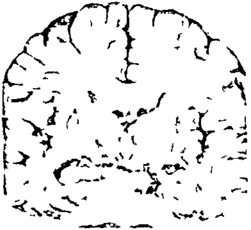


Fig 6 Coronal section through middle of 3rd ventricle of a brain with a long septum pellucidum portions 3 of the lateral ventricles close together

less than half the a p length of the brain, ranging from 39 % to 50 % with a mean of 44 % The corpus callosum may be thick (Fig 2) or thin (Fig 4) A thick corpus callosum is not always short nor is a thin corpus callosum long In Fig 2 a thick corpus callosum is shown which was 48 % as long as the brain (73 mm to 152 mm), while a thin corpus callosum that was 45 % as long as the brain (78 mm to 173 mm) is shown in Fig 4

The septum pellucidum varies greatly in a p length On the average it is 51 % as long as the corpus callosum but the range is great (30 % to 69 %) This variation is due to a marked variation in the position of the junction of the fornix and corpus callosum In Fig 4 the fornix meets the posterior part of the corpus callosum at the splenium but in Fig 2 the fornix and corpus callosum come together 17 mm anterior to the splenium The septum pellucidum is 73 mm long (66 % of the length of the corpus callosum) in Fig 4 but in Fig 2 the septum pellucidum is only 42 mm long (36 % of the length of the corpus callosum) In subjects with short septi pellucidi the middle parts of the bodies of the lateral ventricles are separated by the fused fornix and corpus callosum (Fig 5) In such a case the encephalogram may suggest a space occupying mass in or just above the posterior part of the body of the corpus callosum In subjects with a long septum pellucidum the middle parts of the bodies of the lateral ventricle are close together (Fig 6) Sometimes a cavum Vergae is present which separates these parts of the lateral ventricles (Fig 7) but this is usually recognized because of the accompanying cavum septi pellucidi

The height of the septum pellucidum varied little and did not seem to be of any practical significance

The vein, or the veins, or the septum pellucidum vary considerably In 20 % of these cases there was no sizeable vein in the septum pellucidum but several small veins, probably too small to be seen radiographically In 80 % of the



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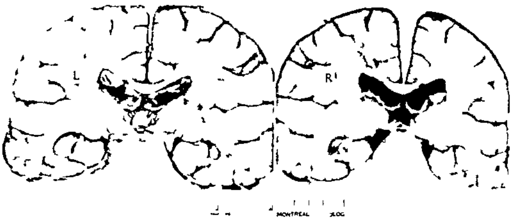


Fig 7 Coronal sections of a brain showing the opposing surfaces of two sections There was a large septum pellucidum a cavum septi pellucidi et Vergae and a cistern of the velum interpositum of average size The relationship of the cavum Vergae to the cistern of the velum interpositum should be noted Pointers indicate the internal cerebral veins which in this case lie close to the inferior surface of the fornices at this level

cases there were one or two sizeable veins in the septum pellucidum The vein *of the septum pellucidum, when single, was usually horizontal* or almost horizontal In 10 % of cases it was vertical or almost vertical (Fig 3), and in 15 % it was oblique

The cistern of the velum interpositum, lying between the roof of the 3rd ventricle and the fornix is more often seen on encephalograms in infants than in adults However, it seemed to be relatively the same size in infants as in adults We got the impression that this cistern was almost horizontal in adults and almost vertical in infants (Fig 8), and this may be the reason why it is filled with gas more often in infants We also got the impression that the long axis of the 3rd ventricle was more vertical in infants than in adults but did not have enough brains of infants to be sure of this When the cistern of the velum interpositum was large, the roof of the 3rd ventricle was relatively low in position

The internal cerebral veins pass backwards in the cistern of the velum interpositum They followed the roof of the 3rd ventricle in the anterior part of their course but posteriorly they sometimes followed the inferior surface of the fornix (Fig 7) especially when the cistern of the velum interpositum was large and the roof of the 3rd ventricle was low The length of the cistern of the velum interpositum was fairly constant Its height varied considerably A high cistern of the velum interpositum seemed due to a low position of the roof of the 3rd ventricle rather than to high position of the fornix A high fornix and a short septum pellucidum were present in only two of the five cases with large cisterns of the velum interpositum

The inferior part of the pericallosal artery as it lies anterior to the lamina terminalis, varies greatly in position It may be as close as 3 mm to the lamina

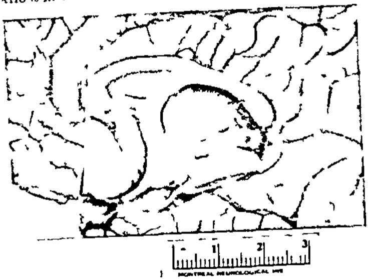


Fig 8 Sagittal section of the brain of an infant the cistern of the ve lum interpositum at its posterior end opens downwards rather than backwards

terminalis or as much as 19 mm anterior to it (Fig 2) One or both peri callosal arteries usually touch the anterior edge of the genu of the corpus callo sum Below the genu the pericallosal arteries vary greatly in relation to each other and to the genu Here, one artery often lies in front of the other rather than side by side Above the genu the superior parts of the pericallosal arteries or their main branches, occasionally pass directly upwards to the cingulate sulcus before turning posteriorly In other cases the superior part of the pericallosal artery follows the corpus callosum rather closely If the posterior part of the body of the corpus callosum has a well marked depres sion the superior part of the pericallosal artery may follow it In such a case, a parasagittal tumor in the anterior part of the parietal lobe may be difficult to exclude In subjects with a short septum pellucidum the corpus callosum dips downwards rapidly to meet the fornix, and in these cases the superior part of the pericallosal artery may also appear depressed suggesting the presence of a parasagittal tumor above it

Conclusions

The a p length of the corpus callosum is 43 % of the length of the brain (range 36 % to 50 %)

The a p length of the septum pellucidum is 51 % of the length of the corpus callosum (range 29 % to 70 %)

The height of the superior surface of the genu of the corpus callosum 53 % of the height of the frontal lobe (range 46 % to 58 %)

The height of the inferior surface of the splenium of the corpus callosum is 30 % of the height of the brain (range 20 % to 43 %)

The corpus callosum has a smooth upper surface in 30 % of cases

The corpus callosum has an irregular upper surface in 70 % of cases This is most often due to a localized depression in the posterior part of the body of the corpus callosum

The septum pellucidum varies greatly in length

The point of junction of the corpus callosum and fornix varies considerably in position

The internal cerebral veins as they lie in the cistern of the velum interpositum follow the roof of the 3rd ventricle anteriorly but may follow the fornix posteriorly

The inferior part of the pericallosal artery does not correspond closely to the lamina terminalis

The superior part of the pericallosal artery has a variable course especially in its posterior part

SUMMARY

The size shape and position of the corpus callosum septum pellucidum and fornix were studied in 35 adult brains by mid sagittal section Other brains were cut in coronal section to facilitate understanding of the sagittal sections The shape and position of the anterior cerebral artery its branches the internal cerebral veins and the veins of the septum pellucidum were also noted Anatomic variations in these structures are described The influence of these variations on the shape of the lateral and 3rd ventricles of the cistern of the velum interpositum and on the course of the midline arteries and veins of the cerebral hemispheres is discussed

ZUSAMMENFASSUNG

Die Grosse die Form und die Lage des Corpus callosum des Septum pellucidum und des Fornix sind in 37 Gehirnen Erwachsener durch sagittale Mittelliniesektion studiert worden Andere Geirne wurden in koronale Sektionen zerlegt um das Verstandnis der sagittalen Sektionen zu erleichtern Die Form und die Lage der Arteria cerebri anterior und ihre Äste der Venae cerebrales internae und der Venen des Septum pellucidum wurden ebenfalls notiert Anatomische Abweichungen dieser strukturen sind beschrieben worden Der Einfluss dieser Abweichungen auf die Form des Seitenventrikels und des 3 Ventrikels auf die Cisterne des Velum interpositum sowie auf den Verlauf der Arterien in der Mittellinie und auf den Venen der Grosshirnshemispharen wird besprochen

RÉSUMÉ

Les dimensions la forme et la situation du corps calleux du septum lucidum et du trigone ont été étudiées sur 37 cerveaux d adultes par section sagittale médiane Des coupes coronales ont été faites sur d autres cerveaux pour aider la compréhension des sections sagittales La forme et la situation de l artère cérébrale antérieure de ses branches et des veines cérébrales internes et des veines du septum lucidum ont aussi été notées Les auteurs décrivent les variations anatomiques de ces structures Ils examinent l influence de ces variations sur la forme des ventricules latéraux et du troisieme ventricule de la citerne du velum interpositum et sur le trajet des artères et des veines de la ligne médiane des hémisphères cérébraux

AUS DER NEUROLOGISCHEN UNIVERSITATSKLINIK (DIREKTOR PROF G SCHALTENBRAND), WURZBURG, DEUTSCHLAND

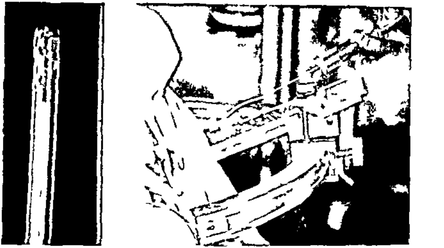
GEZIELTE DARSTELLUNG DES DRITTEN VENTRIKELS MIT PANTOPAQUE

von

M NADJMI und G SCHALTENBRAND

Der Bestimmung intrazerebraler Zielpunkte an den subkortikalen Organen geht im allgemeinen die rontgenologische Darstellung einer benachbarten Orientierungsachse voraus die moglichst geringe Schwankungen aufweist und in einem relativ konstanten Verhaltnis zu dem Zielpunkt steht Es sind lediglich die intrazerebralen Bezugslinien die Interkommissurallinie und die Basislinie die diese Voraussetzungen besitzen, im Gegensatz zu den knochernen Orientierungspunkten und den sog kranio-zerebralen Achsen die einer starken Schwankungsbreite unterliegen

Am 3 Ventrikel konnen die Kommissuren und der hintere untere Rand des Foramen Monroi zur Bestimmung der Basislinie dargestellt werden Dazu werden im allgemeinen neben Luft auch andere Gase oder ein jodhaltiges wasserunlosliches Kontrastmittel wie Pantopaque, Myodil oder Äthjodan, ngewandt Beide Methoden die Pneumoenzephalographie und die positive entrikulographie, haben gewisse Vor- und Nachteile, die je nach dem Alter nd Allgemeinzustand der Patienten die eine oder andere Untersuchung rforderlich machen Hinzu kommt noch, daß der 3 Ventrikel sich mmer im Luftenzephalogramm vollstandig abbildet vor allem wenn ng ist



a b

Abb. 1. a) Punktionsnadel, bestehend aus einem Polyäthylenschlauch und einem Metallmandrin (etwa 5 fach vergrössert). Der Mandrin ist einige Millimeter zurückgeschoben, um die Nadelöffnung sichtbar zu machen. b) Nach Entfernung des Metallmandrins wird das Kontrastmittel durch den Gummischlauch eingespritzt

Unter 300 Luftenzephalogrammen, die aus verschiedenen Indikationen angefertigt worden waren, bei denen aber weder eine Raumbeengung noch ausgesprochener Hydrozephalus zu sehen war, haben wir in etwa 26,6 % die Interkommissurallinie bestimmen können. Zur Untersuchung gelangten vorwiegend die Vorderhorn-Seitenbilder, auf denen man die hintere Kommissur häufiger sah als die vordere. Überdrucksverfahren waren bei dem Liquor-Luft-Austausch nicht angewandt worden.

Bei der positiven Ventrikulographie wird im allgemeinen durch ein Bohrloch einer der Seitenventrikel punktiert und in einer extremen Beuge- oder Strecklage des Kopfes das Kontrastmittel eingespritzt, das anschließend bei entsprechender Lageänderung über das Foramen Monroi in den 3. Ventrikel gelangt.

Wir versuchen den 3. Ventrikel in Zusammenhang mit der in der Würzburger Neurologischen Klinik entwickelten Stereotaxiemethode (SCHALTENBRAND 1959) gezielt über das Foramen Monroi zu erreichen. — Eine isolierte Darstellung des 3. Ventrikels mit Hilfe eines Katheters erreichten AZAMBUJA u. a. (1956).

Im einzelnen gehen wir folgendermaßen vor:

Nach der Fixierung des Kopfes im Kopfhalter wird die Stelle des Bohrloches so ausgesucht, daß der Ventrikeldarstellung unmittelbar der Zieleingriff angeschlossen werden kann. Das Bohrloch befindet sich im vorderen Schädelbereich kurz vor oder hinter der Koronarnaht und in verschiedenen Abständen von der Sagittalnaht, je nach dem Sitz des geplanten Koagulationsherdes.



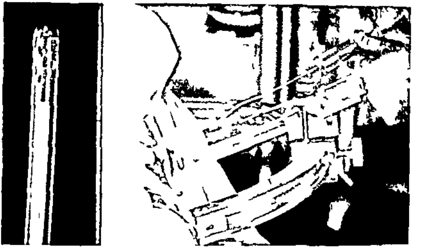
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Abb. 2. a) Die Spitze der Nadel, die sich genau über dem Fadenkreuz projiziert, befindet sich am Zielpunkt (Foramen Monroi). Darstellung des dritten Ventrikels und der lateralen Abschnitte des Seitenventrikels in Seitenlage. b) Das Foramen Monroi befindet sich nicht genau am Zielpunkt, ist aber mit Hilfe Bildwandlers erreicht worden. Darstellung des dritten Ventrikels in Rückenlage

Mit Hilfe erster in zwei Ebenen angefertigter Schädelübersichtsaufnahmen werden die groben Verkantungen durch entsprechende Verstellung des Kopfhalters korrigiert. Danach werden erneut Aufnahmen gemacht, die in nassem Zustand in vierfacher Vergrößerung gegen einen halbdurchsichtigen Schirm projiziert werden. Durch die Gegenprojektion eines entsprechenden Diapositives bringt man die Umrisse eines sagittal geschnittenen Gehirnes mit durchschnittlicher Ventrikelgröße in Deckung mit den Schädelkonturen. Durch entsprechende Justierung kann das Foramen Monroi eingestellt werden.

Die Punktionsnadel, die nun eingeführt wird, besteht aus einem flexiblen Schlauch, dessen Spitze einer Cushing-Nadel ähnelt, und einem Metallmandrin. Ein plötzlicher Abfall des elektrischen Widerstandes, der während der Punktion laufend gemessen wird, weist auf den Ventrikeldurchbruch hin. Am Zielpunkt wird der Mandrin entfernt, und unter Kontrolle des Bildwandlers injiziert man zuerst einige Tropfen Pantopaque, um die genaue Lage des Schlauches zu kontrollieren, der im Bedarfsfall einige Millimeter vor- oder rückwärts verschoben werden kann.

Wenn die Schlauchspitze sich so nahe am Foramen Monroi befindet, daß das Kontrastmittel unmittelbar in den 3. Ventrikel fließen kann, werden während der Injektion von 3 bis 4 ml Pantopaque Aufnahmen im a. p. — und seitlichen Strahlengang angefertigt. In Rückenlage fließt das Kontrastm... relativ rasch ab, so daß eine lange Belichtungszeit von etwa 5 bis 6 Sek... während der Injektion erforderlich ist. In Seitenlage können die Aufna...



a b

Abb 1 a) Punktionsnadel bestehend aus einem Polyathylenschlauch und einem Metallmandrin (etwa 5 fach vergrossert) Der Mandrin ist einige Millimeter zuruckgeschoben um die Nadeloffnung sichtbar zu machen b) Nach Entfernung des Metallmandrins wird das Kontrastmittel durch den Gummischlauch eingespritzt

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RÉSUMÉ

Il est indispensable de remplir de contraste le troisieme ventricule pour tracer les lignes de référence dans les opérations stéréotaxiques des régions sous-corticales L encéphalographie ne fournit les lignes nécessaires que dans une petite proportion des cas et il est préférable de remplir le troisieme ventricule avec un moyen de contraste positif (esters iodés) La méthode des auteurs permet de remplir directement le troisième ventricule par un tube de polythene introduit par le trou de Monro sur un fil guide rigide Des films sont pris pendant l injection du Pantopaque celui-ci est retiré du canal rachidien grace a une aiguille spéciale le malade étant assis

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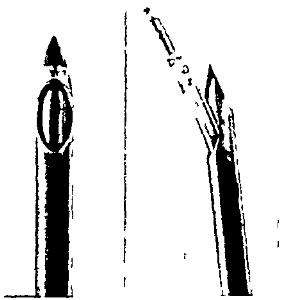


Abb 3 Punktionsnadel mit Polyathylenschlauch zum Absaugen des Kontrastmittels aus dem Spinalkanal

auch unmittelbar nach der Injektion angefertigt werden Das Kontrastmittel kann mit Hilfe einer von uns konstruierten Nadel (HAMPL, NADJMI SCHALTENBRAND) einige Tage spater bei einer Lumbalpunktion wieder abgesaugt werden

ZUSAMMENFASSUNG

Zur Bestimmung der intrazerebralen Bezugslinien bei stereotaktischen Eingriffen an subkortikalen Kerngebieten ist die Kontrastdarstellung des 3 Ventrikels erforderlich Auf dem Luftenzephalogramm konnen nur bei einem gewissen Prozentsatz der Patienten die Orientierungsachsen bestimmt werden Deshalb wird das Ventrikelsystem mit sog Jodestern gefullt Die von uns beschriebene Methode erlaubt eine möglichst direkte Darstellung des 3 Ventrikels mit einem Polyathylenschlauch der mit Hilfe einer starren Sonde gezielt an das Foramen Monroi gebracht wird Es werden wahrend der Pantopaque Injektion Aufnahmen angefertigt Das Kontrastmittel wird aus dem Spinalkanal mit Hilfe einer von uns konstruierten Nadel in sitzender Stellung wieder abgesaugt

SUMMARY

Contrast filling of the third ventricle is indispensable for obtaining intracerebral reference lines in stereotactic operations on the subcortical areas Encephalography will give the required lines in only a small percentage of cases and filling of the ventricle with positive contrast material (iodine esters) is to be preferred The method permits direct filling of the third ventricle via a polythene tube advanced towards the foramen of Monro with a rigid guide wire Films are obtained during the injection of Pantopaque this is eventually removed from the spinal canal by means of a special needle with the patient sitting

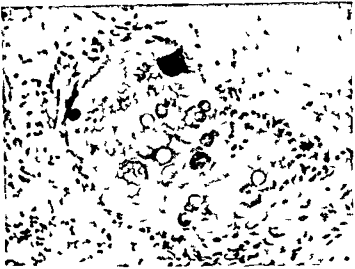


Fig 1 Clumps of coccidioidal spherules some containing numerous endospores

meninges are some of the organs affected (8) Coccidioidal meningitis may be part of an acute generalized infection or may be present in a more chronic form in which it may be the only known site of disease In either case the prognosis of coccidioidal meningitis has been uniformly fatal (2 10 11 12 16)

The radiologic aspects of pulmonary and osseous coccidioidomycosis have been well described by previous authors (4 9 17) and will therefore not be discussed here No reports describing the roentgen studies of coccidioidal meningitis however have been found

The pathologic features of central nervous system coccidioidomycosis (1 5 6 18) consist of marked exudative fibrotic meningeal reaction usually limited to the basal subarachnoid cisterns Inevitably an obstructive hydrocephalus develops which probably accounts for the high mortality rate Occasionally, coccidiodal granulomas may involve the skull and vertebrae and may secondarily affect the central nervous system

In the present study of 21 cases of coccidioidal meningitis the diagnosis was in 16 cases verified by autopsy findings and in the others by serologic studies and/or positive cultures The ages ranged from 3 to 64 years with an average of 31 years In most cases the disease began with a mild upper respiratory infection and in 10 cases roentgenograms of the chest demonstrated pulmonary infiltrates Approximately half of the cases recovered from the respiratory infection and were then asymptomatic for a period averaging 3 months Symptoms of neurologic disease became evident only after this latent period In the other cases central nervous system symptoms developed either during or shortly after the initial respiratory infection

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COCCIDIOIDAL MENINGITIS — ROENTGEN AND PATHOLOGIC ANALYSES

by

THOMAS H NEWTON and NORMAN H COHEN

Coccidioidal meningitis consistently produces a dense basal leptomeni
leading to obstructive hydrocephalus and death This disease, ther
provides a unique opportunity to study the roentgen appearance of
arachnoiditis and to correlate these findings with the observed patho
changes

Coccidioidomycosis is a fungus disease endemic to certain and parts
southwestern United States, particularly to the San Joaquin Valley of
fornia The causative organism, *Coccidioides immitis*, is a plant parasite th
the tissue phase is a thick walled spherule It measures 5 to 50 micr
diameter, and is filled with numerous endospores (Fig 1) These spore
liberated by rupture of the wall Transmission of the disease occurs by inha
of the spore form which is present in the soil

The primary coccidioidal infection may be asymptomatic or may m
itself as a self limited respiratory infection Progressive disseminated d
occurs in less than 0 2 per cent of all primary infections (12) The re
lymph nodes, spleen, skin and subcutaneous tissues, liver, kidneys bone

This study was supported in part by Public Health Service Training Grant 213—51
the National Institute of Neurological Diseases and Blindness Public Health Service



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Table

Pathologic changes in coccidioidal meningitis No roentgen examinations were performed in Cases Nos 11 to 16 inclusive Cases Nos 5 8 and 10 were omitted because no post mortem examinations had been performed

Case No	1	2	3	4
Signs of increased pressure	Yes	Yes	Yes	Yes
Involvement of ventricles				
Generalized ventricular dilatation	3rd & Lat only +++	+++	+++	+
Intraventricular involvement				
Lateral	0	0	0	0
Third	0	0	0	0
Fourth	Occluded	0	0	Occluded
Ependymitis	0	+++ C	CKASE	++ C
Occlusion of foramina of Monro	0	0	0	0
Occlusion of aqueduct of Sylvius	•	0	0	0
Occlusion of foramina of fourth ventricle	+++	++	+++	++
Involvement of subarachnoid spaces				
Supratentorial supracerebral arachnoiditis	0	0	+	0
Subtentorial supracerebellar arachnoiditis	0	0	+	0
Obstruction of cisterns				
Chiasmatic	•	++	+++	++
Interpeduncular	++	++	+++	++
Ambient	++	++	+++	++
Pontine	++	++	+++	+
Magna	++	++	++	•
Cerebellopontine angle	++	++	++	+
Obstruction of spinal subarachnoid spaces				
Cervical	++	+++	+++	•
Thoracic	0	++	++	
Lumbar	0	+	+	•
Cauda equina	0	+	•	

• = none present + = Mild ++ = Moderate +++ = Marked

The most common neurologic signs consisted of papilledema nuchal rigidity hyperreflexia, loss of vision, spastic paresis, pathologic reflexes and cerebellar ataxia Nystagmus and involvement of the fifth, sixth, seventh, and eighth cranial nerves were occasionally noted

Lumbar punctures generally showed moderate to marked increased pressure A considerable cellular content consisting predominantly of lymphocytes was

Table *(cont)*

6	7	9	11	12	13	14	15	16
Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
+++	+++	+++	+	+	4th only ++	++	+++	+++
0	0	Granu	0	0	0	0	0	0
0	0	lomatous	0	0	0	0	0	0
0	0	ventri	0	0	0	0	0	0
++ C	++ C	culitis	+ C	+ C	C& ASE	0	++ C	++ C
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
++	++	+++	0	0	0	++	++	+++
0	0	0	0	+	+	+	+	+
0	0	0	0	+	+	++	++	0
+++	++	+++	•	+	++	++	+++	++
	++	++	++	++	+++	+++	+++	++
++	•	++	•	++	++	++	+++	++
++	++	+++	++	+	+++	++	+++	+++
+	−	++	•	+	++	++	+++	++
+++	++	++	•	+	++	++	++	+++
+	+++	+++	++	++	+++	+++	++	++
+	+++	++	0	−	•	+	++	++
0	++	0	0	0	•	0	++	++
0	++	0	0	0	•	0	•	+++

= Not described C = Chronic ASE = Acute sub pendymitis

found in the cerebrospinal fluid The total cerebrospinal fluid proteins were increased whereas chlorides and glucose were moderately decreased

The course of the illness was usually that of progressive increased intracranial pressure with severe headache vomiting confusion, stupor, deepening coma, and eventual death The duration of the illness averaged 13 months and death occurred within periods of from two weeks to four and a half years after the



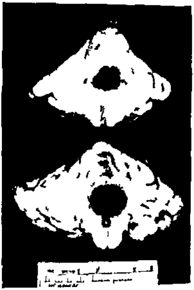


Fig 2 Thick exudate in the region of the interpeduncular cistern (A) fourth ventricle occluded by granulomatous material (B) ventricular dilatation (C)

onset of the central nervous system symptoms Of the 21 patients 19 died and 2 are still surviving four and a half years after the onset of the disease

The clinical and therapeutic features of this disease will be discussed in greater detail elsewhere (3)

Pneumoencephalography and/or ventriculography were performed in eight cases and myelography in two The roentgenographic findings in these cases will now be described and related to the pathologic observations of the entire group

Pathologic findings

Pathologic analyses indicate that the majority of our patients suffered from increased intracranial pressure In most of them, death was caused not by coccidioides within the meninges or nervous tissues, but by obstructive hydrocephalus and spinal subarachnoid blockage This blockage resulted from occlusion of the basal subarachnoid cisterns by reactive fibrosis and granulomatous exudate, preventing the cerebrospinal fluid from reaching the relatively uninvolved subarachnoid spaces over the cerebral convexity

Unfortunately, not all patients had complete roentgenologic studies By reviewing the available pathologic features, however, we are able to predict the radiologic changes that might be expected in this disease For this purpose we have analyzed 13 cases in which the necessary specifically detailed pathologic studies were available and these are listed in the Table

Gross pathologic signs of increased intracranial pressure were noted in 12 of the 13 cases These were most commonly indicated by flattening of the gyri



Fig 3 Granular ependymitis lining the dilated third (A) and lateral (B) ventricles

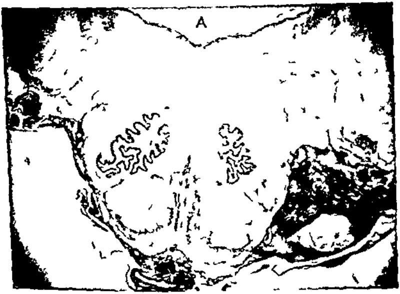


Fig 4 Floor of dilated fourth ventricle (A) in the region of its foramina showing dense enveloping fibrogranulomatous meningitis

but herniation through burr holes was seen in two cases and cerebellar tonsillar herniation was noted once Except for one case in which only the fourth ventricle was dilated, all others had mild to marked generalized ventricular dilatation Significant intraventricular involvement was seen in only 3 cases One patient had diffuse thick granulomatous ventriculitis particularly involving



Fig 5 Moderate ventricular dilatation (A) Dense adhesive arachnoiditis in the chiasmatic cistern enveloping the optic chiasm (B)



Fig 6 Marked coccidioidal fibrogranulomatous meningitis adherent to pons and midbrain occluding pontine (A) and ambient cisterns (B

the lateral ventricles, and in two other cases the fourth ventricle was completely filled with granulomatous material (see B in Fig 2) Ten of our 13 cases showed granular ependymitis (Fig 3) As suggested by RUSSELL (21), this ependymitis may be attributed to tearing of ependymal cells as a result of increased intracranial pressure Occlusion of the foramina of Monro or of the aqueduct of Sylvius was not noted Obstruction of the foramina of the fourth ventricle however was noted to a varying degree in 10 cases (Fig 4) The chiasmatic cistern (B in Fig 5) interpeduncular (A in Fig 2), pontine (A in Fig 6), ambient (B in Fig 6), and cerebellopontine angle cisterns, as well as the cisterna magna

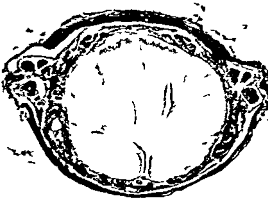


Fig 7 Cervical cord surrounded by markedly fibrotic meningitis



Fig 8 Nerve roots of cauda equina (A) surrounded by severe chronic granulomatous and fibrous leptomeningitis (B)

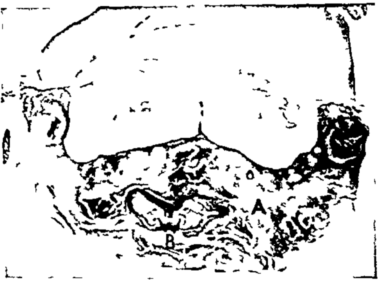


Fig 9 Thick fibropurulent exudate (A) surrounding vertebral arteries (B) striking example of thrombotic panarteritis

were involved by fibrous and granulomatous adhesive meningitis in all cases in which these structures were described On the other hand meningeal involvement of the convexities of the cerebrum and cerebellum was less frequent and when present, was minor

Of particular interest was the degree of involvement of the spinal leptomeninges which may simulate a spinal cord tumor clinically (19) Moderate to dense leptomeningitis, often obstructing the spinal subarachnoid space was found in all the 12 cases in which the spinal cord was examined This involvement was usually most marked in the cervical region (Fig 7) but in two cases it extended to the cauda equina (Fig 8) In one of these cases the arachnoiditis was more severe caudally than in the upper spinal cord or base of the brain

The inflammatory changes were almost exclusively limited to the meninges not involving the underlying nervous tissues This feature is in contrast to tuberculous meningitis in which tubercles are commonly found in the underlying cortical tissue

Major vessel thrombosis was observed in only one case in which both vertebral arteries were occluded (Fig 9) Such thrombosis is in contrast to tuberculous and luetic leptomeningitis in which major vascular occlusion is more common (7 14)

Radiologic features

The radiologic diagnosis of adhesive arachnoiditis may be based on the findings *in* skull roentgenograms, ventriculograms, pneumoencephalograms or myelograms



Fig 10 Ventriculography Dilated lateral and third ventricles with air blocked in midaqueduct

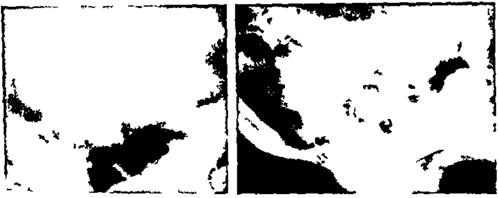


Fig 11 Ventriculography Fourth ventricl markedly dilated due to occlusion of foramina by adhesive arachnoiditis

Although clinical and pathologic evidence of increased intracranial pressure was present in most cases, it usually was not reflected in the ordinary skull roentgenograms In only two cases was there evidence of suture diastasis and in only two were the sellar changes compatible with increased intracranial pressure It is of interest that in two cases of increased convolutional markings flattening of the gyri was noted at postmortem examination This finding suggested that the more prominent convolutional markings, often associated with increased intracranial pressure, are not caused by direct pressure of the gyri against the inner table of the skull

There appeared to be no relation between the duration of symptoms and the changes indicative of increased intracranial pressure seen in the roentgenograms of the skull Intracranial calcification, commonly noted after tuberculous meningitis (14) was not demonstrated in any of the cases of coccidioidal meningitis Calcification was noted microscopically, however, in three of the 16 cases examined

Contrast studies of the central nervous system correlated well with the pathologic findings The roentgen findings were not specific for coccidioidal meningitis, however, since adhesive basal arachnoiditis of many causes may give a similar appearance Air studies in this disease, however, are helpful, both for excluding the presence of a posterior fossa tumor and for showing the presence of obstructive hydrocephalus, thus indicating the need for an early shunt procedure The consistent involvement of the cisterna magna, as well as of the



a b



c

Fig 12 a) and b) Pneumoencephalography Air limited to cisterna magna pontine interpeduncular and cerebellopontine angle cisterns and could not be maneuvered into the distal subarachnoid pathways or into the ventricles c) Ventriculography Lack of communication between fourth ventricle and subarachnoid spaces

spinal subarachnoid spaces however, precludes the use of a ventriculosubarachnoid shunt

The high incidence of adhesive arachnoiditis gives the radiologist an excellent opportunity to study the appearance of leptomeningitis involving primarily the basal cisterns and the spinal subarachnoid spaces

The roentgen diagnosis of basal arachnoiditis is usually based on the lack of communication of the ventricular system and of the subarachnoid spaces with consequent ventricular dilatation (13) Ventricular dilatation was present in all cases examined and in all but one involved the entire ventricular system In one case (Fig 10), air introduced into the lateral ventricles was blocked in the midaqueduct and on postmortem examination granulomatous exudate filled the fourth ventricle Obstruction of the fourth ventricle or aqueduct, by a small tumor, or by noninflammatory stenosis may give a similar appearance and must always be considered in the differential diagnosis

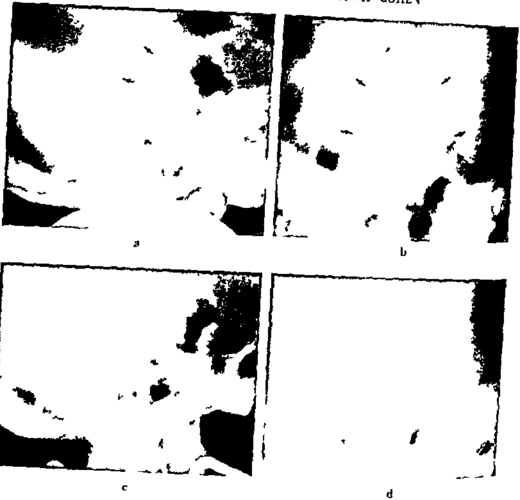


Fig 13 a) and b) *Pneumoencephalography* Normal appearance of cisterns with normal filling of ventricular system. c) and d) *Pneumoencephalography* 2 years later Cerebellopontine angle cisterns now appear smaller and ventricles and distal subarachnoid cisterns could not be filled

In three cases no air could be passed from the dilated fourth ventricle into the subarachnoid spaces at the time of ventriculography (Fig 11)

Pneumoencephalography proved to be valuable in establishing the diagnosis of arachnoiditis involving either the spinal meninges or the basal subarachnoid cisterns The diagnosis of arachnoiditis may be based on one of the following findings (1) failure of ventricular filling, (2) distortion of or nonfilling of the subarachnoid cisterns, (3) change in size of the subarachnoid cisterns or (4) distortion or blockage of the spinal subarachnoid spaces

The failure of ventricular filling at pneumoencephalography is not in itself sufficient for the diagnosis of basal arachnoiditis This lack of filling may be due entirely to incorrect positioning of the head or to too rapid injection of a



Fig. 14. Pneumoencephalogra[illegible] with neck slightly flexed. Air [illegible] and blocked a[t] first cervical vertebra.



Fig. 1[illegible] [illegible]

Moreover, it may be impossible to fill the ventricles in such lesions as p[osterior] fossa tumors (22) with or without tonsillar herniation, or supratentorial tumors especially those with transtentorial herniation. In such cases, however, the basal cisterns and superficial subarachnoid channels fill and the correct diagnosis may often be made even in the absence of ventricular filling.

The partial or complete obliteration of the basal cistern due to adhesive arachnoiditis may be recognized by the distortion or nonfilling of these spaces at pneumoencephalography. The lack of cisternal filling again may, however, be due to technical errors in positioning or improper injection of air. The examination therefore may need to be repeated to confirm the diagnosis. RUGGIERO (20), in discussing the diagnosis of arachnoiditis of the cerebellopontine angle, suggested that this diagnosis should not be considered unless repeated pneumoencephalography shows the same appearance of nonfilling of this cistern.

An adhesive process about the midbrain is strongly suggested when the cisterns about this structure fail to fill with air. In our experience such a process was present when the ambient and quadrigeminal cisterns and the superficial subarachnoid channels and ventricles failed to fill. At the same time however air readily filled the cisterna magna and the interpeduncular and cerebellopontine angle cisterns but did not progress beyond these spaces.

Distortion or block of the spinal subarachnoid spaces may be recognized at myelography or at pneumoencephalography, and occasionally at ventriculography. In two instances, air introduced via the lumbar subarachnoid route was blocked in the cervical subarachnoid space (Fig. 14). In one case ventriculography showed air in the cervical subarachnoid space displaced anteriorly, presumably by the presence of a thick arachnoiditis which was found on post mortem examination (Fig. 15).

Myelograms available in two cases showed extensive distortion and block of the pantopaque column (Figs 16 and 17). The myelographic appearance of spinal arachnoiditis may be difficult to differentiate from other abnormalities such as vascular malformations, extensive ependymomas, or other diffuse neoplasms. Contrast medium lying in the subdural or epidural space may also simulate the appearance of chronic arachnoiditis and thus presents difficulty in diagnosis.

We have had no experience with arteriography in coccidioidal meningitis. Except for thrombosis of both vertebral arteries in one case, no other vascular abnormalities were noted pathologically. Subdural effusions and venous thromboses, so common in pyogenic meningitis of infancy, were not observed in our cases.

SUMMARY

Coccidiodal meningitis produces an exudative fibrotic meningeal reaction involving basal cisterns and spinal subarachnoid spaces, shown radiologically by distortion or obstruction of basal or spinal subarachnoid spaces leading to hydrocephalus. These findings are not specific but may be found in various other types of arachnoiditis. In view of the increase in traveling, however, coccidioidal meningitis should be considered even in nonendemic areas when radiologic findings suggest adhesive arachnoiditis.

ZUSAMMENFASSUNG

Coccidium Meningitis verursacht eine exudative fibrotische meningeale Reaktion in den basalen Cysternen und spinalen subarachnoidalen Räumen. Das Röntgenbild zeigte Deformierung oder Obstruktion der basalen oder spinalen Subarachnoidalräume was Hydrocephalus zur Folge hatte. Diese Befunde sind nicht spezifisch und können bei verschiedenen anderen Formen von Arachnoiditis gefunden werden. In Anbetracht des ansteigenden Reiseverkehrs sollte man daher auch in nicht endemischen Gebieten an Coccidium Meningitis denken wenn die Röntgenbefunde eine Arachnoiditis vermuten lassen.

RÉSUMÉ

La méningite de la coccidioidose provoque une réaction méningée exsudative fibreuse qui intéresse les citernes de la base et les espaces sous arachnoidiens rachidiens; ces lésions se traduisent radiologiquement par une déformation ou une obstruction des espaces sous arachnoidiens basaux ou rachidiens, conduisant à l'hydrocéphalie. Ces signes ne sont pas spécifiques mais peuvent exister dans divers autres types d'arachnoidite. La fréquence croissante des voyages doit faire envisager le diagnostic de méningite coccidioidienne, même en dehors des régions d'endémie, quand les

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FROM THE DEPARTMENTS OF RADIOLOGY AND SURGERY (NEUROSURGERY), STATE UNIVERSITY OF NEW YORK UPSTATE MEDICAL CENTER AT SYRACUSE, U.S.A.

RADIOLOGICALLY CONTROLLED INJECTIONS THROUGH THE FORAMEN OVALE FOR RELIEF OF TIC DOULOUREUX AND OF PARKINSONISM

by

THEODORE PERL and ARTHUR ECKER

Since 195[illegible] we have been treating tic douloureux by alcohol injection of the trigeminal root and ganglion (ECKER & PERL 1958). We use the anterior approach through the cheek and foramen ovale developed by [illegible] 193[illegible] and HARRIS (1940) and modifications of the radiographic [illegible] technique introduced by PENMAN (1950, 1953). Our method provides [illegible] precision to produce numbness in the trigger area while sparing sensation in the rest of the face, especially in the cornea.

In 195[illegible] we began to use the foramen ovale to reach the thalamus for relief of the tremor and rigidity of Parkinsonism (ECKER & PERL 1960). The details of this method are described under a special heading.

Tic douloureux

[illegible] FERNER (1949) has shown that the trigeminal sensory root is a network bathed in cerebrospinal fluid (Fig. 1). The ganglion is canoe shaped with the root fibres entering into its concave side. The junction of root and ganglion is only 4 to 5 mm from the posterior margin of the foramen ovale. When the head is in the position for the needle insertion, the ophthalmic fibres are lowest in Meckel's cavity.

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a b

Fig 3 Radiographic technique a) The patient lies supine body elevated on a mattress head is extended until the orbitomeatal line makes an angle of 65 with the vertical (the orbitomeatal needle angle) b) Head is rotated to the opposite side until the sagittal line makes an angle of 15 with the vertical (the sagittal needle angle) the central ray is directed through grid

Radiographic technique Guidance lines are drawn on the patient s head and a wire grid taped on the cheek at the approximate entry point (Fig 2) Recently before radiography, we have been injecting 10 ml of procaine (1 %) in the cheek in the tissues anterior and medial to the coronoid process This produces local anesthesia Distending the cheek fixes the position of the entry point more securely by preventing movement of the skin Thickening the tissue on the inner aspect of the coronoid process minimizes the possibility of penetration of the oral mucosa

The head is placed with the use of plastic guides (Fig 3) The roentgenogram shows the foramen ovale in relation to the wire grid (Fig 4) In our earlier work we obtained three preliminary films but now only one If this is correct the final entry point is marked on the skin However if the foramen is not demonstrated properly, additional films are obtained after appropriate adjustment of one or both angles Observation of the dried skull is helpful in determining the degree of adjustment

Needle insertion When the final entry point has been determined the grid is removed antiseptic solution is placed on the skin and the head is repositioned An additional 1 ml of procaine is injected intradermally at the entry point The needle 21 gauge 4 long with trocar pointed stylet is placed at the entry point and inserted vertically downward, again under biplane guidance (Fig 5) Penetration of the foramen ovale is determined by the operator s feel of the needle (resistance and sudden yielding as in penetration of the dura for

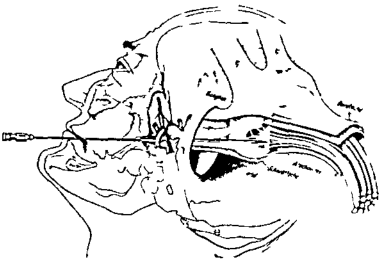
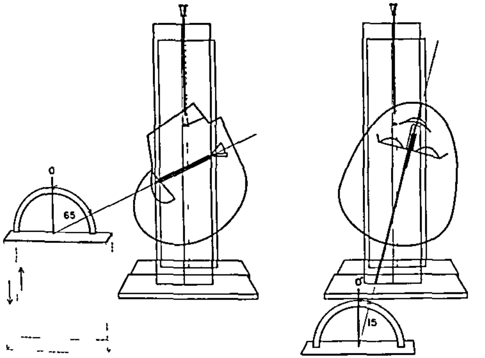


Fig 1 Section of skull in vertical plane rotated 20 away from the para sagittal The correctly placed needle lies in this plane Gasserian structures have been left intact Inset trigeminal root and ganglion (after FERNER) demonstrating that the trigeminal root is often a loose meshwork of fibres bathed in cerebrospinal fluid and that the ganglion is canoe shaped

When sighting through the cheek and foramen ovale of the dried skull, one can rotate the skull to see the petrous ridge just above the inferior margin of the foramen In fact, one can see the groove in the ridge made by the trigeminal root This line of sight from the eye through the center of the foramen to the trigeminal groove is the line of the needle insertion The radiographic problem is to determine both the position of the head which makes this line vertical and the point where this line meets the skin, the entry point for the needle



Fig 2 Radiographic determination of head position and entry point for vertically downward insertion of needle Guidance lines and wire grid as follows mid sagittal line on forehead orbitomeatal line on cheek from external canthus of eye to external auditory canal approximate entry point midway between coronoid process of mandible and lateral wall of maxillary sinus at the level of the corner of the mouth the wire grid 2 cm on each side is taped on the cheek with its center at the approximate entry point



a



b c

Fig 5 Needle insertion The plastic guides are placed in line with the final entry point and taped to the table The radiologist sights from the head end and the technician sights simultaneously from the side of the table through the plastic guides a) The head position is controlled by observing the orbitomeatal needle angle and sagittal needle angle b) The entry point kept in line c) The needle is kept vertical as it passes through the tissues

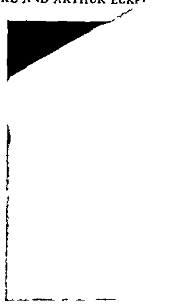


Fig 4 Ap oblique The final entry point on the skin is marked in the same relation to the grid as the center of the foramen ovale is to the grid on the film

lumbar puncture) and by the production of momentar
needle should penetrate about 4 mm Two roentgeno
For the first, the face is rotated 5° toward the unaffected si
jection of the hub over the tip of the needle (Fig 6a) T
entrance of the needle through the foramen For the second, the
for the basal view, the central ray being directed through the
foramen ovale The stylet is withdrawn exactly 1 cm and fixed in
by means of a 1 cm long stop devised by PENMAN (1950, 1953)
radiolucent distal 1 cm of the needle as a ruler, we determine the
intracranial depth of the tip of the needle (Fig 6b) The depth can be a
by use of a ruler on the cheek alongside the needle

When the stylet of the properly placed needle is removed, spinal fluid
escape Since the tip is between fibres of the root, the needle is slowly w
drawn until the flow just ceases The tip is now at the juncture of the root
ganglion in the hollow of the canoe shaped ganglion It is near the third
second division fibres, an ideal location for injection This point is only
5 mm deep to the posterior edge of the foramen Even if no cerebrospinal f
is obtained when the stylet is withdrawn, the tip of the needle is brought
5 mm deep to the posterior margin of the foramen ovale, rather than
10 to 15 mm suggested by PENMAN

We no longer make a preliminary intracranial injection of procaine W
the needle has been properly placed, one or more small therapeutic injecti
of only 0 05 ml of absolute alcohol are made with careful sensory testin im
diately after each We are particularly concerned with preserving corr
sensation If there is unwanted anesthesia of the cornea and forehead
needle is withdrawn 2 mm and the face is immediately rotated further tow

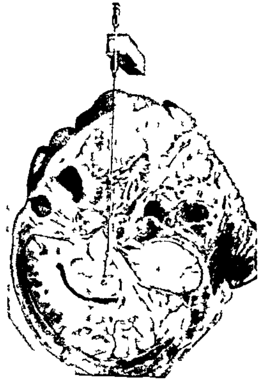


Fig 7 Oblique section made through the plane of the needle insertion showing the needle traversing cheek foramen ovale temporal lobe and internal capsule Its tip is in the target area in the thalamus

Parkinsonism

Anatomy The target area is in the antero inferolateral portion of the thalamus (COOPER & BRAVO) (Fig 7) According to the atlas of SPIEGEL and WYCIS (1957) the target in the normal brain lies 16 mm lateral to the midline and 10 mm in front of the posterior commissure 2 mm above the intercommissural line

The needle will traverse the cheek the mandibular nerve in the foramen ovale, the dural roof of Meckel s cavity the temporal lobe and the posterior limb of the internal capsule which lies just antero-inferolateral to the target and embraces it The needle penetrates the bottom of this cup Reflux of the injected alcohol is stopped by the tough internal capsule and therefore alcohol collects on the target in the bottom of the cup

Radiographic technique Three roentgenograms are made with a special opaque centimeter ruler extending along the orbitomeatal line from the external auditory canal to the front of the right orbit as follows the first a basal view (Fig 8 a and b) the second an anteroposterior (a p) view (Fig 8c) obtained with the patient supine and the orbitomeatal line perpendicular to the tabletop

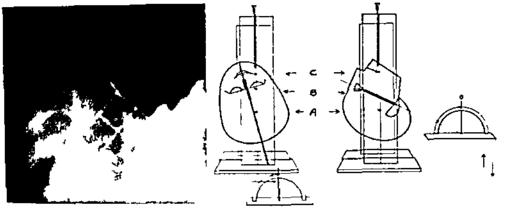


a b

Fig 6 a) The a p oblique film is obtained with the head rotated 5 medial to the position for insertion so that the hub clears the tip This confirms penetration of the foramen b) The basal view is obtained with the stylet withdrawn exactly 1 cm The relatively radiolucent distal 1 cm of the needle is used to measure the depth of penetration beyond the posterior margin of the foramen This needle is 15 mm deep we now prefer it to be 4 mm

the healthy side This allows the lighter alcohol to rise in the spinal fluid in Meckel s cavity above the corneal fibres The corneal anesthesia usually disappears *In this manner we control the exact location and degree of anesthesia* When the desired anesthesia and analgesia in the second and third divisions persist for thirty minutes, the needle is removed Frequently, analgesia of the alveolar process alone is sufficient to relieve pain If several minutes after injection sensation of the trigger area returns, the depth of the needle is checked by another basal view and re adjusted if necessary before another injection of alcohol is made In our experience, corneal anesthesia has never resulted when the needle has been within 5 mm of the foramen and not more than 0 05 ml of absolute alcohol were injected at one time

Results Over a period of seven years, more than 100 cases have been injected There has been immediate relief in all cases and, up to the present, *long lasting* relief in 85 % In the 15 % where anesthesia disappeared and pain recurred a second injection brought prompt and prolonged relief A third injection has rarely been required The method is safe and effective There have been no serious complications and no deaths Fifteen percent have had corneal anesthesia However, in all of these cases, either the needle was deeper than 5 mm beyond the posterior edge of the foramen ovale, or more alcohol was injected at one time than the 0 05 ml we now recommend None of the cases required tarsorrhaphy or developed a corneal scar The technique requires the cooperation of radiologist surgeon and patient



a b

Fig 9 a) Determination of the entry point of the needle The head is positioned with the target foramen line vertical by extending the head until the required angle between the orbitomeatal line and the vertical is obtained The face is then rotated to the opposite side until the sagittal line makes the required angle with the vertical With the projection of the target foramen line vertical in both planes the target foramen line is vertical A film obtained with the wire grid on the cheek will yield the final entry point the projection of the target foramen line to the skin This point the center of the foramen ovale is marked on the skin in relation to the wire grid b) Insertion of the guide needle The head is placed in the position in which the roentgenogram for determination of the entry point was made with the entry point foramen line vertical The guide needle is inserted vertically downward under biplane guidance just through the foramen

and with an additional opaque centimeter ruler placed parallel to the table opposite the external auditory canal, the third a cross table lateral view obtained with this ruler placed in the mid sagittal plane (Fig 8d)

The projected position of the foramen ovale (B) and target (A) are determined on the a p and lateral views The angle between the target foramen line and the orbitomeatal line is called the orbitomeatal needle angle, that between the target foramen line and the sagittal line the sagittal needle angle These angles are used to position the head and to determine the entry point The target foramen lines as drawn on the a p and lateral views, are projections of the true target foramen line (CBA) (see Fig 9b)

The entry point (C) is the extension of the target foramen line to the skin The patient is placed supine with the head extended and positioned as for the preliminary trigeminal roentgenogram with the grid centered on the approximate entry point on the cheek This film will show the foramen ovale (Fig 9a) The center of the foramen ovale is marked on the skin in relation to the grid The proposed needle course the vertical line through the entry point foramen ovale and target has now been determined

The needle is inserted in two stages Antiseptic solution is placed on the skin and the cheek is locally anesthetized The head is placed so that the line CBA is vertical A guide needle is inserted under biplane guidance as in the trigeminal injection (Fig 9b) The guide needle is 19 gauge 6 long trocar

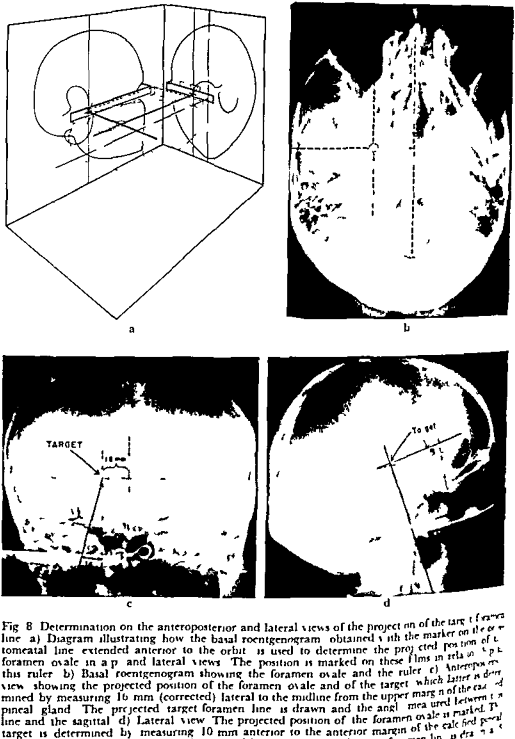
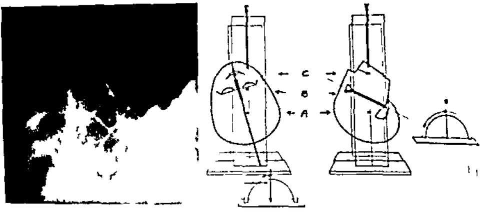


Fig 8 Determination on the anteroposterior and lateral views of the projection of the target foramen line a) Diagram illustrating how the basal roentgenogram obtained with the marker on the orbitomeatal line extended anterior to the orbit is used to determine the projected position of the foramen ovale in a p and lateral views The position is marked on these films in relation to this ruler b) Basal roentgenogram showing the foramen ovale and the ruler c) Anteroposterior view showing the projected position of the foramen ovale and of the target which latter is determined by measuring 16 mm (corrected) lateral to the midline from the upper margin of the calcified pineal gland The projected target foramen line is drawn and the angle measured between this line and the sagittal d) Lateral view The projected position of the foramen ovale is marked The target is determined by measuring 10 mm anterior to the anterior margin of the calcified pineal along a line 8 cephalad of the orbitomeatal line The projected target foramen line is drawn [illegible] the angle measured between this line and the orbitomeatal line



a b

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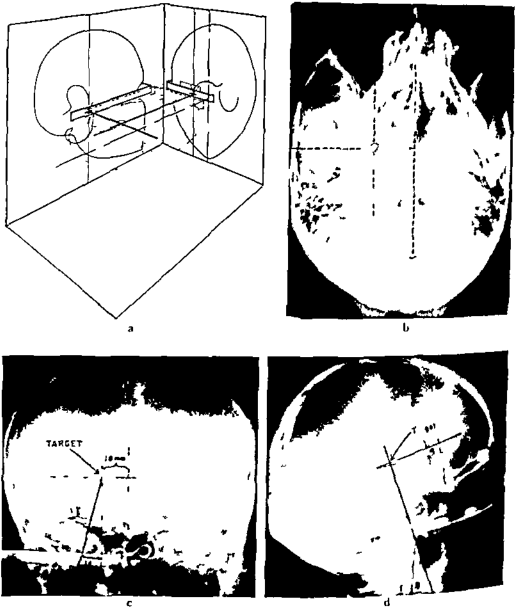


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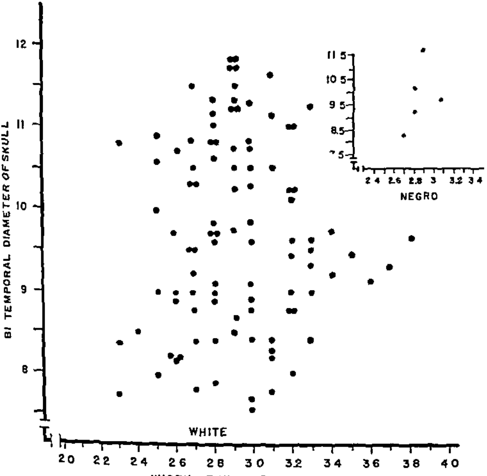


Diagram 1 Narrowest bi temporal diameter of skull and width of incisura at the level of posterior clinoids in 100 white and 24 negro males

3 9 cm Half way toward the apex, before the final convergence the width may increase or decrease by a few millimeters The length of the skull is only very generally related to the length of the incisura which ranges from 3 9 to 6 1 cm

On the other hand for those interested in details Diagrams 1 to 3 give a definite account of craniometric and incisural data for each individual case

In Fig 4 of a narrow tentorial aperture the free edges point not toward each other but forward and parallel to each other and to the sagittal plane The other extreme was observed in a case of gargoylism or Hurler s syndrome with a nearly circular tentorial opening measuring about 8 cm in width (PLAUT 1961, Fig 3 a diagram Fig 4, in the same monograph shows different

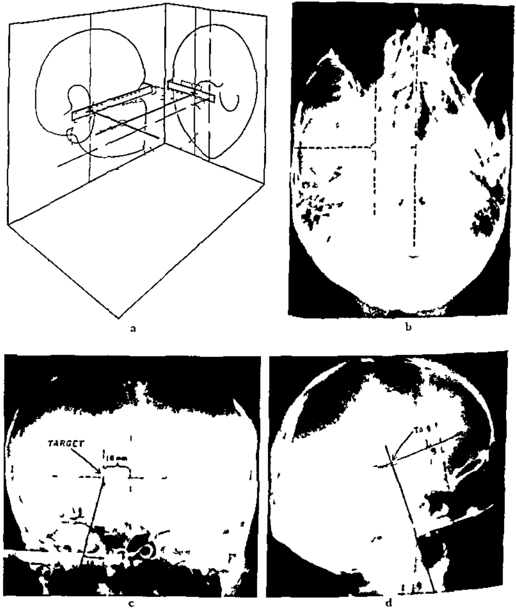


Fig 8 Determination on the anteroposterior and lateral views of the projection of the target [illegible] line a) Diagram illustrating how the basal roentgenogram obtained with the mark[illegible] on the [illegible]tomeatal line extended anterior to the orbit is used to determine the projected position of the foramen ovale in a p and lateral views The position is marked on these films in relation to this ruler b) Basal roentgenogram showing the foramen ovale and the ruler c) Anterop[illegible] view showing the projected position of the foramen ovale and of the targ[illegible] which la[illegible] determined by measuring 16 mm (corrected) lateral to the midline from the upper margin of the [illegible] pineal gland The projected target foramen line is drawn and the angle measured bet[illegible] line and the sagittal d) Lateral view The projected position of the foramen ovale is marked [illegible] target is determined by measuring 10 mm anterior to the anterior margin of the calcified [illegible] along a line 8 cephalad of the orbitomeatal line The projected target foramen line is dra[illegible] the angle measured between this line and the orbitomeatal line



Fig 11 Final needle insertion Using care to hold the guide needle in place the final needle is advanced the required distance to the target A p and lateral films are obtained to verify the position of the final needle before injecting procaine If the procaine (0 1 ml) produces a satisfactory result (suppression of tremor and rigidity on the contralateral side) one or more injections of 0 1 ml of the alcohol Hypaque mixture are made Then a p and lateral films are obtained to demonstrate the size shape and position of the lesion

Results This procedure has been performed 15 times in 10 patients All were unilateral injections There was relief of the major symptoms tremor and or rigidity on the contralateral side in each case However in five of the cases it was necessary to make a second injection for permanent relief The condition of one patient was made worse In two cases with bilateral facial grimaces prolonged relief was produced by a single unilateral injection These results have been presented in greater detail elsewhere (ECKER & PERL 1960)

SUMMARY

A method of inserting a needle through the cheek and foramen ovale is described For the permanent relief of tic douloureux alcoholic injection is recommended Since 1934 more than 100 cases have been relieved of pain without serious complications In the treatment of the tremor and rigidity of Parkinsonism the preliminary radiographic study determines the target the entry point on the cheek and the position of the head for the vertically downward insertion of a 19 gauge guide needle just through the foramen Further radiographic studies control the insertion of a 28 gauge needle through the guide needle to the target and also demonstrate the therapeutic lesion produced in the target area of the thalamus



Fig 10 A p and lateral roentgenograms with the guide needle in place Th mattress elev patient s trunk is removed and the head is positioned so that the orbitomeatal line is vert c and cross table lateral films are obtained with the stylet withdrawn exactly 1 cm With the aid preliminary a p and lateral films the target is marked Using the radiolucent distal 1 cm of the g needle as a ruler the distance between the guide needle tip and the target is determined

tipped and has an opening at its side near the tip The final needle emerges through this at an angle of 12° (Fig 11) The direction of this can be controlled but the preliminary studies are planned so that it is anterior to the line of the guide needle This enables us to correct any slight error in the direction of the guide needle and allows us to use a more convenient entry point higher on the cheek

After insertion of the guide needle a p and lateral films are obtained with the stylet of the guide needle withdrawn exactly 1 cm (Fig 10) Measurements on these films determine the distance to the target beyond the tip of the guide needle The final needle is then inserted the required distance A p and lateral films are obtained to verify this position

Procaine and alcohol injection First, 0 1 ml of 1 % procaine is injected and neurologic tests for rigidity and tremor made If the result is satisfactory 0 1 ml of a mixture of absolute alcohol (5 parts) and Hypaque (1 part) is injected one or more times as required to relieve tremor and rigidity Final anteroposterior and lateral roentgenograms are then obtained promptly to demonstrate the size shape and position of the lesion (Fig 11)

We believe that this method has the following advantages (1) no general anesthesia is necessary, (2) burr hole in the skull is avoided, (3) the use of a very fine needle to penetrate the brain minimizes the risk of hemorrhage in the basal ganglia, (4) full exposure of the head permits accurate radiography

FROM THE DEPARTMENT OF NEUROSURGERY (DIRECTOR PROF PH PHILIPPOV)
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ROENTGENOLOGIC DIAGNOSIS OF CEREBRAL CYSTICERCOSIS

by

PH PHILIPPOV

The roentgenologic diagnosis of cerebral cysticercosis ordinarily depends upon the demonstration of the calcified cysts of the cysticercus cellulosae Encephalography and ventriculography may however prove to be of great value in this condition and capable of demonstrating early lesions still amenable to treatment and not demonstrable by conventional roentgenography

Cerebral cysticercosis may be divided into three forms depending on the situation of the lesions (1) parenchymatous (2) intraventricular and (3) basal

The parasite in the parenchymatous form lies in the substance of the cerebrum, cortex and subcortex and subpial regions and produces characteristic changes in the ventricular system and subarachnoid spaces The ventricular system is moderately dilated but as the spread of the cysts is never equal in the two hemispheres, the dilatation of the lateral ventricles bears a definite relationship to the involvement of the hemispheres the ventricle on the side with the larger quantity of parasites always being slightly wider than the other The difference in the size of the lateral ventricles is considerably more marked when the lesions are situated only in one hemisphere

The changes in form of the ventricles in the parenchymatous form of cerebral cysticercosis are produced by a process displacing the inner cranial space and by post inflammatory atrophy

ZUSAMMENFASSUNG

Eine Methode fur die Einfuhrung einer Nadel durch die Backe und das Foramen ovale ist beschrieben Um eine permanente Heilung der Trigeminus Neuralgie zu erreichen wird Alkoholinjektionen empfohlen Seit 1954 sind mehr als 100 Falle ohne ernsthafte Komplikationen geheilt worden An Hand von radiographischen Studien wird — bei der Behandlung von Tremor und Rigiditat bei Parkinsonismus — die Zielrichtung Einstichstelle sowie die Lage des Kopfes bestimmt wobei eine 19 Gauge Führungsnadel vertical in distaler Richtung durch das Foramen eingefuhrt wird Unter weiterer radiographischer Kontrolle geschieht die Einfuhrung einer 28 Gauge Nadel uber die Fuhrungsnadel und die therapeutisch gesetzte Lasion im Zielbereich des Thalamus wird demonstriert

RESUMÉ

Les auteurs décrivent une méthode pour introduire une aiguille à travers la joue dans le trou ovale Pour la guérison définitive du tic douloureux l injection d alcool est recommandée Depuis 1954 plus de 100 cas ont été guéris sans complication sérieuse Pour le traitement du tremblement et de la rigidité de la maladie de Parkinson une étude radiographique détermine la région cible le point d entrée sur la joue et la position à donner à la tete pour introduire verticalement une aiguille guide de calibre 19 exactement à travers le trou ovale D autres radiographies contrólent l introduction d une aiguille de calibre 28 vers la cible dans l aiguille guide Elles montrent aussi la lésion thérapeutique produite dans la région cible du thalamus

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The roentgenologic diagnosis of cerebral cysticercosis ordinarily depends upon the demonstration of the calcified cysts of the cysticercus cellulosae Encephalography and ventriculography may however prove to be of great value in this condition and capable of demonstrating early lesions still amenable to treatment and not demonstrable by conventional roentgenography

Cerebral cysticercosis may be divided into three forms depending on the situation of the lesions (1) parenchymatous (2) intraventricular and (3) basal

The parasite in the parenchymatous form lies in the substance of the cerebrum cortex and subcortex and subpial regions and produces characteristic changes in the ventricular system and subarachnoid spaces The ventricular system is moderately dilated but as the spread of the cysts is never equal in the two hemispheres the dilatation of the lateral ventricles bears a definite relationship to the involvement of the hemispheres the ventricle on the side with the larger quantity of parasites always being slightly wider than the other The difference in the size of the lateral ventricles is considerably marked when the lesions are situated only in one hemisphere

The changes in form of the ventricles in the parenchymatous form of cerebral cysticercosis are produced by a process displacing the inner cranial spaces by post inflammatory atrophy

of the lateral ventricle if it is situated in the wall If the cysts lie free within the lumen of the ventricle they may be evident in lateral views outlined by air as they lie on the surface of the fluid A spherical defect in the filling may also sometimes be seen in those parts of the ventricular system situated in the mid line most often in the fourth ventricle

Cerebral angiography reveals no characteristic changes

Conclusion

Cerebral cysticercosis may produce typical pneumoencephalic and ventriculo graphic appearances The parenchymatous (cortical) form is characterized by moderate homolateral hydrocephalus with displacement towards the side of the smaller lateral ventricle, and evidence of cysts in the subarachnoid spaces The intraventricular form consists of defects that represent the actual cysts in grossly dilated ventricles free cysts in the lumen of the ventricles may also be demonstrated as irregularities in the fluid air margins Marked hydrocephalus without defects in the ventricular system is usually encountered in the basal form of the condition

Editor s note The paper read before the Symposium was richly illustrated but is now published without the illustrations.

SUMMARY

Cerebral cysticercosis may produce characteristic encephalographic and ventriculographic appearances The parenchymatous intraventricular and basal forms of the condition are considered in detail

ZUSAMMENFASSUNG

Cysticercose des Gehirns kann typische encephalographische und ventrikulographische Bilder verursachen Die parenchymatose intra ventrikulare und basale Form der Erkrankung werden im Detail beschrieben

RÉSUMÉ

La cysticercose cérébrale peut donner des signes encéphalographiques et ventriculographiques caractéristiques L auteur étudie en détail les formes parenchymateuses intraventriculaires et basales de cette affection

The displacement produced by the cysts in the substance of the cerebral hemisphere reduces the inner cranial space and together with a unilateral pressure exerts an influence on the position of the ventricles This does not occur in any other pathologic condition in the brain Displacement towards the side of the larger ventricle is always observed in, for instance cases of neoplasm, but in the parenchymatous form of cysticercosis the displacement is always towards the side of the smaller ventricle so that its larger companion is on the side of the pressure effect

Two changes may be observed in the subarachnoid spaces The first consists of diffusive obliterations of the subarachnoid spaces with scattered dilatations in the form of lakes, or of unequally dilated subarachnoid spaces widely spread over the whole convexity of the cerebral hemisphere The second change that is characteristic of the parenchymatous form of cerebral cysticercosis consists of dilatation of the subarachnoid spaces on the convexity of the hemispheres, in the middle of which lie peculiar spheric or slightly oval defects These are usually sharply outlined and vary in density from the centre outwards The translucencies may vary also in size, from a pea to a bean, depending upon their situation and may be single in a defined region of the cortex or be spread over the surface of the hemisphere

The defects are usually most clearly evident in profile encephalograms and occupy a position in the regions where the subarachnoid spaces are widest such as the frontal and fronto temporal regions, the zone of the cistern of the Sylvian fossa and more rarely in the parieto occipital region They may be difficult to demonstrate in frontal views but may often be shown at the convexity

The mechanism of the production of the defects is as follows The air driven into the subarachnoid spaces displaces the fluid owing to the free intercommunication between the spaces The cysts projecting into the spaces from the surface of the brain or the subpial zone, or those cysts that lie entirely in the subarachnoid spaces either freely movable or adherent to the arachnoid membrane, constitute foreign bodies filled with fluid and displace the air in the subarachnoid spaces They thus produce filling defects

The appearances of the basal form of cerebral cysticercosis are essentially those of hydrocephalus The lateral ventricles are markedly dilated but not displaced The third and the fourth ventricles and the aqueduct are usually also dilated In this form of the disease the basal cisterns are obliterated by parasites contained in them and the accompanying inflammatory process (arachnoiditis), as a result of which 'hydrocephalus occlusus sine occlusione' (H H Bourdenko) is produced The subarachnoid spaces are usually not filled at ventriculography even if patent

The intraventricular form of cerebral cysticercosis is characterized by a marked to a high degree of symmetric dilatation of all the parts of the ventricular system The parasite may sometimes be defined as a defect in the outl

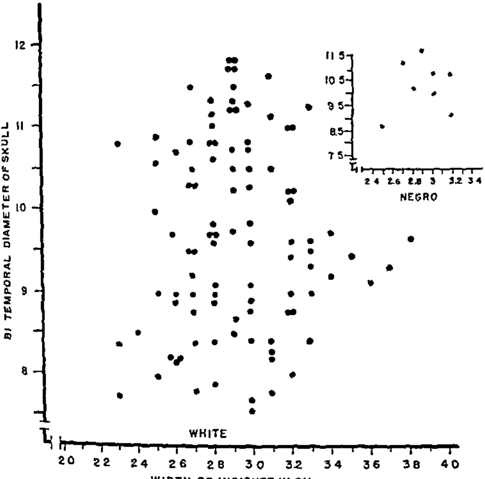


Diagram 1 Narrowest bi temporal diameter of skull and width of incisura at the level of posterior clino ds in 100 white and 24 negro males

3 9 cm Half way toward the apex before the final convergence the width may increase or decrease by a few millimeters The length of the skull is only very generally related to the length of the incisura which ranges from 3 9 to 6 1 cm

On the other hand for those interested in details Diagrams 1 to 3 give a definite account of craniometric and incisural data for each individual case

In Fig 4, of a narrow tentorial aperture the free edges point not toward each other but forward and parallel to each other and to the sagittal plane The other extreme was observed in a case of gargoylism or Hurler s syndrome with a nearly circular tentorial opening measuring about 8 cm in width (PLAUT 1961, Fig 3, a diagram, Fig 4 in the same monograph shows different

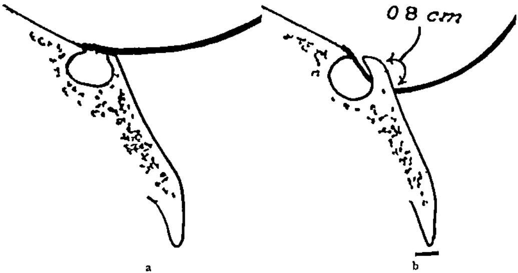


Fig 3 a) Schematic illustration of the free tentorial margins seen from the side as they extend from the posterior to the anterior clinoids in about 60 % of our cases b) In about 40 % of cases the free rim may lie 1 to 8 mm below the level of the dorsum (This low position may facilitate a descending tentorial herniation)

mass may create a basal shift It 'carries the brain stem to the opposite side which increases the interval between it and the free edges of the tentorium on the same side as so well explained and illustrated by SUNDERLAND (Fig 481) Fifty tentorial openings were measured by him and a few by others (GRIGOROWSKY, CORSALLIS 1958 and KINAL)

Present material Our own studies were started to determine a possible interdependence between the size and shape of the skull and of the tentorial incisura The widest biparietal and narrowest bitemporal diameters and the width between the free edges of the tentorial notch were measured in 124 skulls All crania were measured with calipers by the author after removal of the scalp, post mortem The size of the incisura was taken with a small rigid ruler Great effort was made to get accurate figures while the falx remained attached to the skull anteriorly and posteriorly The width at the midpoint of aperture was determined after removal of the supratentorial brain structures The incisural length was taken in a straight line from the apex to the dorsum sellae It was usually checked again after cutting the falx In some cases for technical reasons, not all the measures could be ascertained Our patients came from different ethnic stock and represent a cross section of midwestern U S population This also holds true for the negro patients

For those readers who 'never look at graphs the following may be stated no significant relation exists between the diameter of the skull at the temporal or parietal level and the width of the tentorial incisura It varies from

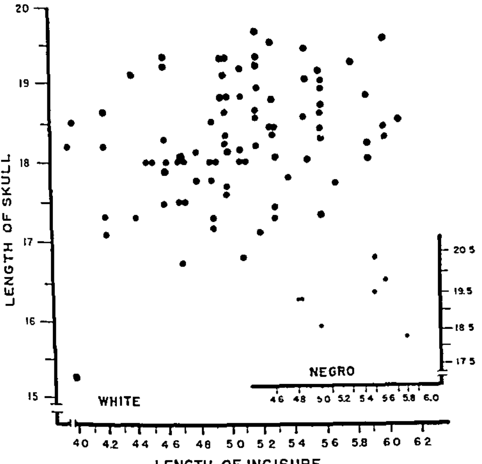


Diagram 3 Length of skull compared to length of tentorial incisura

view offers an excellent opportunity to compare the right and left sides with each other (Fig 7) Half axial views demonstrate the embracement of the brain stem by the superior cerebellar and posterior cerebral arteries (Fig 8) Compression or displacement of the pons are easily discovered and the fine cerebellar branches are well demonstrated up to and along the midline

A mental picture of the location of the aperture may help to recognize abnormalities in clinical cases Cerebral herniations through the tentorial notch can be shown by the course of arteries and deep venous channels in angiography and by the shift of brain structures using air or oil for contrast

Location size and rate of growth of intracranial masses determine the direction of cerebral dislocation Herniations may occur in a lateral direction under the falx and in a sagittal direction forward and upward or backward

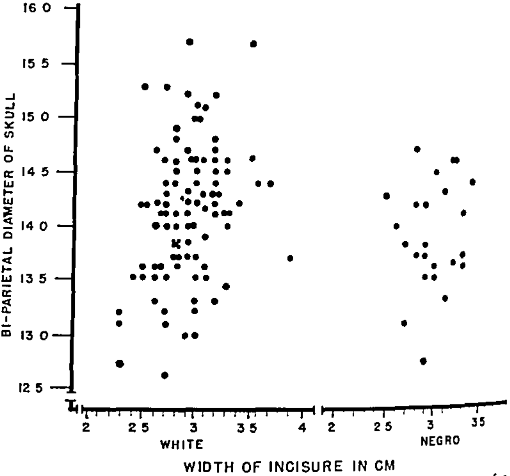


Diagram 2 Widest parietal part of skull and width of incisura The dot marked 4 represents four identical data the cluster marks five

configurations of the incisura in actual size and is accompanied by two tables grouping 100 tentorial measurements)

The posterior attachment of the tentorium is quite frequently outlined by air in a wide angle in the encephalogram This contour does not bring to the attention of the observer the anterior convergence of the tentorial leaves t the narrow aperture for the passage of the brain stem with its centers for respiration and other important functions

In the living the incisura has been outlined by tentoriographs in a few cases (TALAIRACH, DAVID, FISCHGOLD & ABOULKER 1951) Our diagrams in Figs 5, 6, 7 are based on roentgen demonstration of the tentorial incisura on the cadaver by means of metal foil, clipped to the free edges and barium paste painted on the leaves In the lateral vertebral arteriogram the posterior cerebral artery is seen situated above the tentorial edge The fronto-occipital

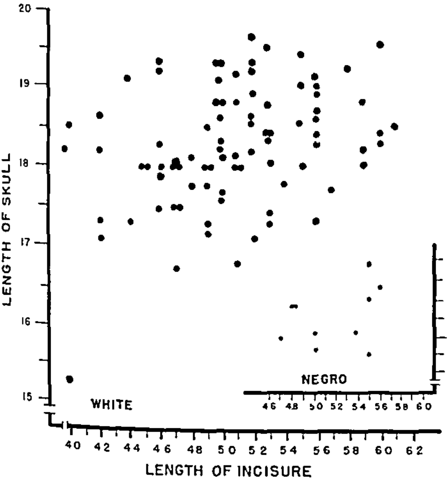


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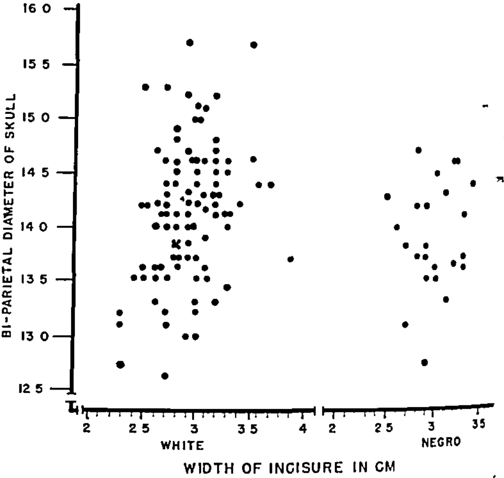


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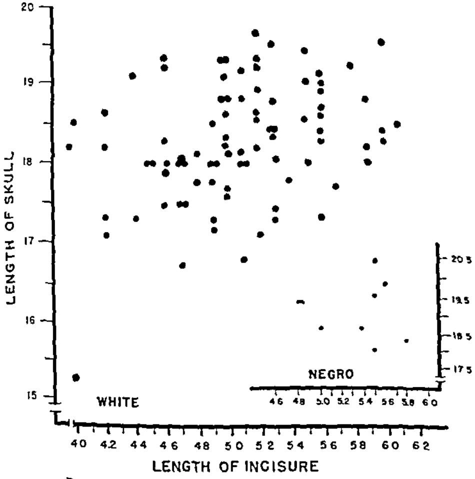


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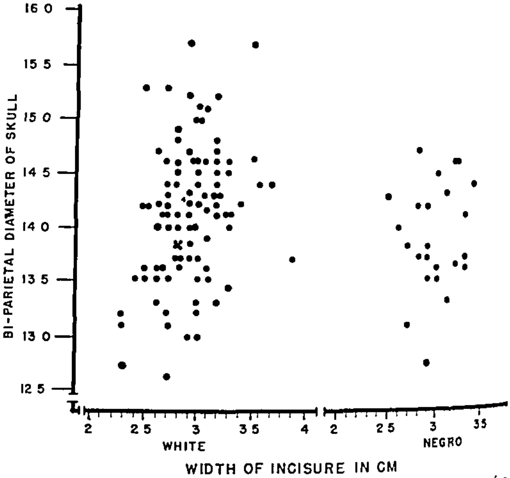


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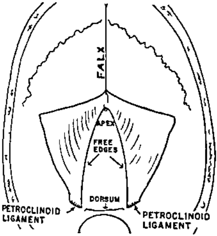


Fig 5 Schematic drawing of fronto-occipital roentgenograms of tentorial leaves arising posteriorly from occiput and laterally from petrous portions of temporal bone Apex of incisura is formed by the convergence of the free margins toward each other Petroclinoid ligaments are not part of the free tentorial edges

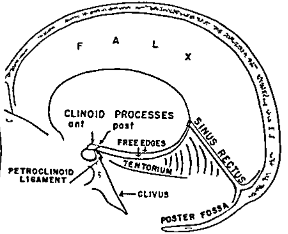


Fig 6 Schematic illustration of the tentorium in the lateral roentgenogram attached laterally to the superior edge of the petrous portion (pyramid) and anteriorly to the clinoid processes (When the petroclinoid ligaments calcify they can be seen on roentgenograms in vivo)

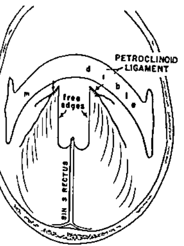


Fig 7 Drawing derived from roentgenograms of the tentorial leaves in axial projection (see figs 1 and 2) It locates the free edges in relation to the petroclinoid ligaments which extend from the tip of the petrous (pyramids) to the posterior clinoids

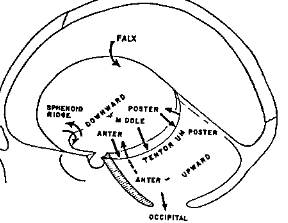


Fig 8 Schematic illustration of various cerebral herniations from one intracranial space to the other and through the foramen magnum (Reproduced with kind permission of Charles C Thomas publisher from PLAUT 1961)

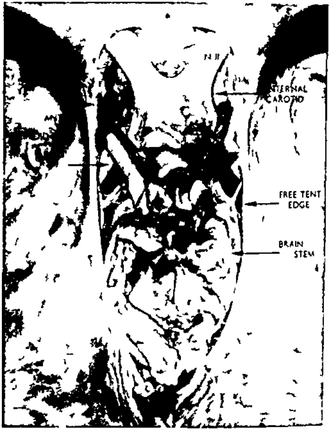
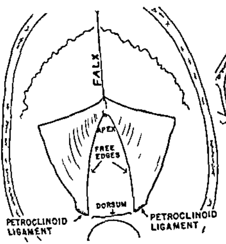


Fig 4 View from above of a narrow (2 5 cm) tentorial incisure fitting snugly around the brain stem It is not significant that the bi temporal diameter of the skull is also narrow (8 cm)

and downward over the sphenoid ridge (Fig 8) A descending herniation into the tentorial notch results from supratentorial pressure An ascending herniation can be produced by expanding lesions in the subtentorial space below one or both tentorial leaves or, more centrally, in the region of the pons medulla and clivus Occipital herniation through the foramen magnum is not as frequent as downward and upward cerebral dislocation through the tentorial incisure (Azambuja, Lindgren and Sjogren)

Cerebral herniations can be demonstrated by pneumograms and by means of arteriograms In the carotid arteriogram the anterior choroid artery can be seen as a fine vessel often in the lateral view, but neither as well nor as often in the frontal projection A much better indicator of vascular changes near the tentorial aperture is the posterior cerebral artery, because it is fairly large and courses above the free edge It can be demonstrated in about 25 % of carotid



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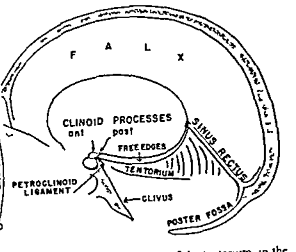
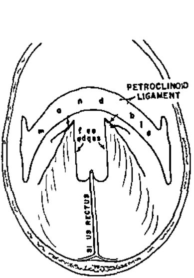


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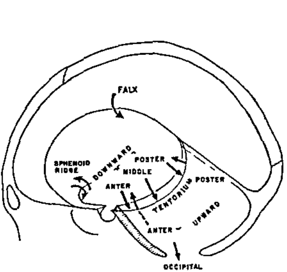


Fig 8 Schematic illustration of var ous cerebral herni ations from one intracranial space to the other and through the foramen magnum (Reproduced wi permission of Charles C Thomas publisher from 1961)

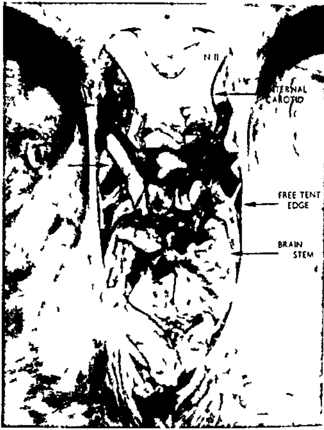


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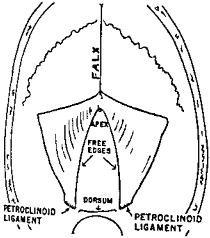


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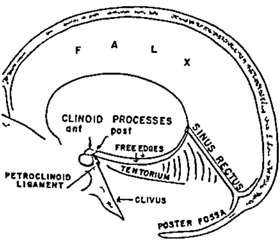


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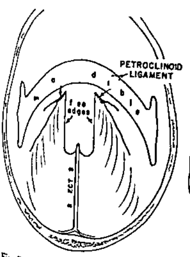


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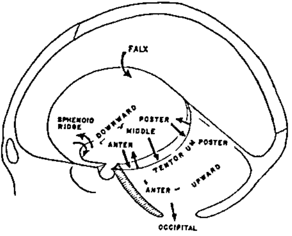
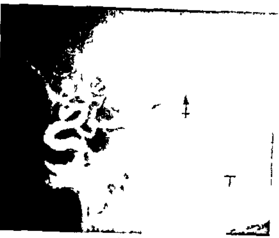


Fig 8 Schematic illustration of various cerebral herniations from one intracranial space to the other and through the foramen magnum (Reproduced with kind permission of Charles C Thomas publisher from PLAUT 1961)



a



b



c

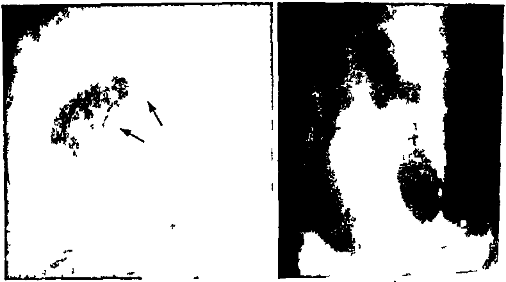
Fig 10 Case 2 a) Frontal ... t r gram The left vertebral artery en l ab r l ... at th level of the foramen m gnum \ ... m ll curved arteries extend fan l ke up a ... t l t occipital region and about 1 cm to th ... ll They lead to a tumor mass of about ... f a ... and eins Bas lar or right vertebral a t r a r t filled b) La teral arteriogram of comm n car tid art ry The wide posterior communicating artery s di placed d wnward and forms a sharp angle v th the posterior cerebral artery Whereas the second port on of the posterior cerebral artery is slightly depressed the th rd portion is elevated A tumor (T) is contrast filled be ng partly supplied by the occipital branch of the external carotid artery c) Fronto-occip tal left carotid arteriogram Considerable medial displacement of posterior com municating artery and of second port on of posterior cerebral artery indicating anter or descending tentorial herniation In contrast there is lateral displacement of the third portion with flattening of its (normally sharp laterally open) angle prov ng posterior ascending herniation The tumor (T) is faintly outlined No cer ebral displacement across the midline under the falx

Case reports

Descending tentorial herniation

Case 1 A 7 year-old boy had an episode of nose bleeding after a fall Two months later he as readmitted to hospital with right sided headache vomiting lethargy and weakness of the ft lower facial movements A vascular tumor was suspected (Mr Roth) Trephination of e skull yielded no evidence of subdural hematoma or intracerebral hemorrhage Finally e patient was admitted a third time at the age of 13 about two months after he had struck s head against the dashboard of an automobile He suffered a contusion of nose and lip and puted Lumbar puncture yielded xanthochromic spinal fluid

Lateral carotid angiography revealed downward angulation of the posterior com unicating artery and a shallow downward displacement of fine abnormal arteries as



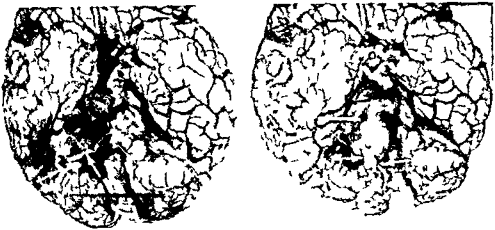
a b

Fig 9 Case 1 a) Lateral ventriculogram brow up A mass of 4 cm diameter (on film) bulges with a nearly semicircular border upward and forward into the right ventricle (arrow) b) A.p view The mass is impinging with a sharp convex border from the right and above upon the third ventricle (arrow) and displaces the right temporal horn laterally (Courtesy of A J BROCAS and G F JOPLIN)

in [illegible] unilaterally and about 3 % bilaterally In about 8[illegible] % the [illegible] artery is supplied by the vertebral system and has proved [illegible] landmark in our study of more than 300 vertebral angiographies

[illegible] vertebral angiogram permits a comparison between the [illegible] terior cerebral arteries because as a rule they are both filled [illegible] also may reveal compression of the contralateral posterior cerebral [illegible] against the sharp tentorial edge on the uninvolved side lead[illegible] [illegible] and brain damage with ipsilateral neurologic signs

[illegible] p lying developmental, vascular, traumatic, inflammatory and neo[illegible] bral lesions can often and early be detected in the venous phase In the [illegible]teral phlebogram the internal cerebral vein can become elevated depressed [illegible] flattened or foreshortened It is not always easy to interpret displacement [illegible] the basal vein of Rosenthal in relation to tentorial herniation This [illegible] courses along the medial margin of the temporal lobe above the uncus [illegible] then surrounds the brain stem along the ambient cistern It joins the great vein of Galen, which may become compressed by masses from below or above changing its curve and the angle it forms with the straight sinus In the frontal view a lateral displacement of the internal cerebral vein can be demonstrated even if carotid angiography is performed on the uninvolved [illegible]



a b

Fig 11 Case 3 Base of brain at autopsy with large thrombosed aneurysm of the basilar artery involving the distal portions of both vertebral arteries It lies to the right of the midline (Mr R C Metzger) The caliber of the right vertebral artery (↔) is 9 mm three times the size of the firm, solidly thrombosed left one (→) b) Arteriosclerotic irregularities and discolorations of the distal basilar artery and its bifurcations By spreading the brain apart from the large aneurysm the condition becomes better visible The pons has been compressed from the right side and the right superior cerebellar and posterior cerebral arteries displaced upward

Acknowledgements

The author wishes to thank Drs D B Roth S W Nelson and William Molnar for permission to use their clinical material and J A Davis Ph D for statistical evaluation of the measurements The medical illustrators Miss Mary Maciel and Mr P F Fairchild our Chief Medical Illustration Service Mr F J Van Dyke and his assistant Mr M A Anthony have shown great skill and understanding of the task on hand Mrs Sue A Sharp has been untiring and of great help in her secretarial function

SUMMARY

The width of the tentorial incisura varies from 2 3 to 3 9 cm independently of the width of the skull In 40 percent the free tentorial edges do not fasten to the posterior clinoids in a continuous line A low site of the anterior free margin may facilitate descending tentorial herniation The borders of the tentorial opening are demonstrated on the cadaver in lateral frontal and half axial roentgenograms Unusual examples of herniation through the tentorial incisure are illustrated

ZUSAMMENFASSUNG

Die Weite der tentoriellen Incisur variiert von 2 3 bis 3 9 cm unabhängig von der Schädelbreite In 40 % der Fälle sind die freien Tentoriumränder nicht kontinuierlich an den Processus clinoidei posteriores befestigt Ein Tiefstand des vorderen freien Randes kann eine descendierende tentorielle Herniierung begünstigen Die freien Ränder der Tentoriumöffnung werden an der Leiche in lateraler frontaler und halbaxialer Röntgenaufnahme demonstriert Ungewöhnliche Fälle von Herniierung durch die tentorielle Incisur werden illustriert

well as stretching of the anterior choroid artery All signs indicated a descending tentorial herniation The findings were confirmed by ventriculography (Fig 9) and by immediately following craniotomy An old hematoma was discovered in the right lateral ventricle It was covered by a membrane and had the size of a lemon In addition there existed an arteriovenous malformation (Mr J B McMillan with microscopic calcification in the walls of the vessels) which extended into the thalamic region Both were successfully removed

Posterior ascending and anterior descending herniation

Case 2 A 59 year old man had a grand mal seizure ten months before admission He then developed progressive difficulty in walking and blurred vision

The lateral arteriogram showed the left vertebral artery supplying numerous vessels along the floor of the posterior fossa leading to a tumor outlined by contrast medium and continuing into veins which were larger than normal There was no filling of the basilar artery and its branches As may be seen in the frontal view (Fig 10a) many small arterial branches in the region of the posterior fossa lead to the tumor

On the lateral carotid arteriogram (Fig 10b) there is downward displacement and angulation of the posterior communicating artery and of the second portion of the posterior cerebral artery which are signs of anterior descending tentorial herniation In addition the third portion is elevated by the subtentorial mass indicating posterior ascending herniation through the apex of the incisura The anterior choroid artery is not well demonstrated The a p view of the carotid artery (Fig 10c) shows medial convexity and displacement of the posterior communicating artery and the second portion of the posterior cerebral artery On the other hand the third portion of the posterior cerebral artery is displaced laterally and flattened into a shallow curve indicating posterior upward tentorial herniation

These findings were confirmed by posterior fossa craniotomy with removal of a tumor arising from the undersurface of the left tentorial leaf The histologic diagnosis was angioblastic meningioma (Mr J W Old) Death occurred on the eleventh postoperative day and autopsy was performed

Ascending herniation into anterior part of tentorial incisure

Case 3 A 76-year-old woman complained of frontal headaches and dizziness for several years She had lateral nystagmus right facial weakness and left positive Babinski

In the lateral view of the skull curvilinear calcifications were situated above and behind the sella and a large aneurysm was suspected The patient later became comatose and remained in that condition for 5 months before death

Post mortem a large aneurysm of the basilar artery was discovered (Fig 11a) which involved the distal portions of both vertebral arteries and measured 5 cm in length and 2 4 × 2 4 cm in width and thickness After spreading the space between the right temporal lobe and the pons the compression and upward displacement of the brain stem is well seen (Fig 11b The right superior cerebellar and posterior cerebral arteries are shifted medially and upward signifying ascending herniation into the anterior part of the tentorial incisure

The Third Symposium Neuroradiologicum in London 1953 has accomplished much in stimulating the interest in tentorial herniations Careful post mortem examination of the region of the incisura is necessary to discover shifts of brain structures This experience at autopsy will make it easier to recognize tentorial herniation on roentgenograms of the living at an early stage when surgical operation may prove life saving



a

Fig 11 Case 3 Base of brain at autopsy with large thrombosed [illegible] lar artery in volving the distal portions of both vertebral arteries It lies to the rig[illegible] Mr R C Metzger The caliber of the right vertebral artery (←) is 9 mm th[illegible] the firm solidly thrombosed left one (→) b) Arteriosclerotic irregularities an[illegible] the distal basilar artery and its bifurcations By spreading the brain apart from th[illegible] d tion becomes better visible The pons has been compressed from the right side a[illegible] cerebellar and posterior cerebral arteries displaced upward

Acknowledgements

The author wishes to thank Drs D B Roth S W Nelson and William Molnar for permission to use their clinical material and J A Davis Ph D for statistical evaluation of the measurements. The medical illustrators Miss Mary Maciel and Mr P F Fairchild our Chief Medical Illustration Service Mr F J Van Dyke and his assistant Mr M A Anthony have shown great skill and understanding of the task on hand Mrs Sue A Sharp has been untiring and of great help in her secretarial function

SUMMARY

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RÉSUMÉ

La largeur du foramen ovale de Pacchioni varie entre 2 3 et 3 9 cm indépendamment de la largeur du crane Dans 40 pour cent des cas le bord libre de la tente ne s attache pas aux clinoides postérieures par une ligne continue La situation basse de la partie antérieure du bord libre peut faciliter une hernie tentorielle vers le bas Les bords de l orifice de la tente sont rendus visibles sur le cadavre sur des radiographies de face de profil et en incidence fronto-sous occipitale L auteur donne des exemples inhabituels de hernies par l incisure de la tente

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INSTITUT DE RADIOLOGIE (DIRECTEUR PROF. A. VALLEBONA), DE L'UNIVERSITE DE GENES, ITALIE

L'AGRANDISSEMENT DE L'IMAGE RADIOGRAPHIQUE EN NEURORADIOLOGIE ET LES DIVERS ASPECTS DES VASCULARISATIONS PATHOLOGIQUES

par

GIORGIO RAMELLA et ROMEO BOCCACCIO

Le diagnostic angiographique de nature des neoplasies cerebrales trouve un des plus grands coefficients de possibilités dans les divers aspects morphologiques des vaisseaux de formation nouvelle et dans les differentes modalites d'irroration de la tumeur. Les etudes sur cet argument sont desormais nombreuses et les caracteres pathologiques des vaisseaux assez bien definis.

Notre etude n'a donc pas éte spécialement dirigee sur la recherche plus minutieuse de nouveaux elements de jugement, mais sur la tentative d'ameliorer les possibilités analytiques de l'image angiographique dans le but de mettre en evidence les élementes les plus utiles. C'est dans ce but que nous avons cru utile de suivre la voie de l'agrandissement de l'image radiographique sur l'exemple d'experiences faites dans d'autres secteurs du radiodiagnostic. Nous avons naturellement consideré tout d'abord les possibilites et les limites offertes par les deux methodes classiques de l'agrandissement: la geometrique et l'optique. La premiere de celles ci qui devrait sans autre donner les resultats les plus avantageux pour leur qualites intrinseques, c'est à dire la possibilite de selectionner les divers elements selon leur profondeur dans l'objet avec un effet particulier de pseudorelief a du etre ecartee par nous pour des raisons pratiques evidentes. En effet, les images realisables, à cause de l'insuffisante puissance des tubes radiogenes a feu tres fin, ne presentent pas les caracteres photographiques desirables a moins de vouloir adopter les techniques angio-

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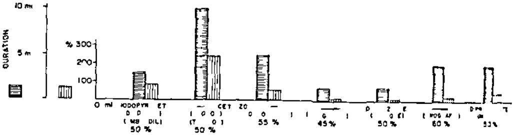
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Increase in blood flow after injections of different contrast media into the carotid artery in a dog of 7 6 kg at one and the same experiment

iodopyracet 35 % and sodium acetrizoate 25 % disturbed the blood brain barrier to the same extent BLOOR, WRENN & MARGOLIS (1951) and WHITELEATHER et coll (1956), using BROMAN & OLSSON s technique, found however that iodopyracet 35 % was far less toxic to the blood brain barrier than sodium acetrizoate 30 %

Sodium diatrizoate was also examined with the same technique by WHITELEATHER (1956) and VOSSE (1960) who considered it the least toxic of the four groups The latter reported that a mixture of the methylglucamine and sodium salts was less toxic than pure sodium diatrizoate and sodium diprotrizoate

BROMAN & OLSSON also recorded changes in blood pressure and blood flow during their experiments, as earlier reported by WEATHERALL (1912) CREITZ (1956), in investigations in human subjects observed a fall in blood pressure and bradycardia even with the small doses of sodium acetrizoate used during rapid serial carotid angiography (4 ml Triurol 50) SJOGREN (1957) found that less bradycardia occurred after diatrizoate 45 % than after sodium acetrizoate 50 % The mixture of methylglucamine and sodium salts (Urografin 45 %) produced less bradycardia than the pure sodium salt (Hypaque 45 %) EISTEIN et coll (1959) reported less bradycardia after 50 % diatrizoate than after 35 % and 40 % iodopyracet

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Carotid angiography in the dog and cat produced a fall in blood pressure and caused bradycardia by the action of the contrast media on the vasomotor structures of the brain, not via the carotid sinus A comparison of the effects of different contrast media demonstrated that sodium acetrizoate was the most active substance, small doses diminished the blood pressure by about 25 % and the heart rate to about the same degree Diatrizoate and diprotrizoate were less active both diminished the blood pressure by 10 % and the heart rate by 6 % *Observation of the blood pressure and heart rate* appeared to be a simple and sensitive method of evaluating the toxicity of contrast media

It was also evident that all four groups of contrast media caused vasodilation of the peripheral vessels with a remarkable increase of the blood flow through the brain These effects were probably produced by vascular paralysis due to a direct action on the smooth muscle cells

The comparison of effects in the dog of different contrast media gave the following results

The first group iodopyracet (Umbradil) administered in a dose correspond ing to 1 to 4 ml into the internal carotid artery of an adult man increased the blood flow to two or three times the resting level for a duration of about 6 minutes

The second group, sodium acetrizoate (Urokon or Triurol were used), had an extremely marked vasodilating effect The injection caused an increase of the blood flow to three to four times the resting level for a period of about 12 minutes The methylglucamine salt of acetrizoate acid seems to have a weaker action than the sodium salt but a stronger one than iodopyracet

The third group consisting of the diatrizoate compounds (Hypaque was used) was the least vasodilating The blood flow was never more than doubled for about 2 minutes

The fourth group sodium diprotrizoate (Miokon) had about the same effect as the third group although the effect was sometimes a little more marked

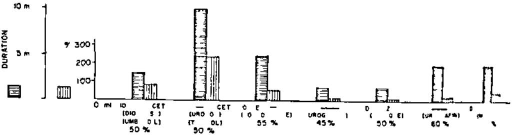
The results of seven successive injections of different contrast media into the same dog are recorded in the figure above Exhaustion tends to change the later responses in such an experiment and the comparison of a number of con trast media in the same animal is not as reliable as the comparison of two

Even if the dilatation of the peripheral arteries may be considered un favourable it is remarkable that there is a parallel between the effect of vasodilation and the toxic effect on the central nervous system

The femoral cutaneous intestinal and vertebral arteries were examined in addition to the carotid artery and were also found to present evidence of marked dilation

Vasodilation or vasoconstriction at cerebral angiography has been discussed It would appear that the experiments reported have established without doubt that contrast media cause vasodilation A degree of vasodilation with an increase of flow through the cerebral vessels of up to five times the resting level as an effect of a roentgen contrast medium has apparently not previously been described

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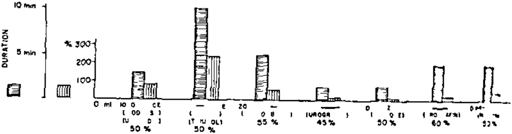
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made in two ways by occluding the descending aorta and injecting the medium above the occlusion, or with the dog supine by diminishing the flow through the aorta in order to layer the contrast medium in the dorsal segmental arteries The flow through the aorta may be diminished by cardiac arrest induced by acetylcholine and certain other substances, by increasing the intrabronchial pressure, or by occluding the caval veins entering the heart The two last methods produce a diminished flow of blood to the heart

Fifty six experiments were carried out in dogs under sodium pentothal anaesthesia The contrast medium was injected into the descending aorta immediately proximal to an occlusion produced by a balloon A double lumen catheter through which the balloon was filled and the medium injected, was introduced via one of the carotid arteries and the aorta occluded at different levels between Th7 and L3 One millilitre of contrast medium per kg body-weight was injected, except in two dogs in which 1 5 ml per kg sodium acetrizoate 50 % were injected

It is shown in the Table above that paresis of the hind legs occurred in 3 out of 8 dogs with one injection of iodopyracet 70 % above the occluded aorta The concentration was decreased to 50 % in a series of 20 dogs no paresis or other complications occurred

The contrast media belonging to the second group sodium acetrizoate, were used in 70 % concentrations in one dog and this animal developed paresis The concentration was diminished to 50 %, and then paresis was produced by the medium in 1 out of 7 dogs

Finally contrast media belonging to the third group (diatrizoate) were tested An injection of 1 ml/kg Urografin 76 % was first made above an occlusion, the latter was then removed for 30 minutes, again imposed and a further injection of the same volume and concentration performed These two injections produced paresis In the subsequent experiment the dose of medium was changed Two injections with a 20 minute interval between them were made into the ascending aorta without occlusion 30 minutes after the second injection the descending aorta was occluded and a third injection of 1 ml/kg diatrizoate 76 % was given above the occlusion One dog developed paresis in the front as well as in the hind legs

The dose in the last 15 experiments was decreased to one injection of 1 ml/kg diatrizoate 76 % into the ascending aorta without occlusion, followed 30 minutes later by one injection of the same volume and concentration above the occluded descending aorta All these 15 dogs survived with no paresis or other complications

Conclusions

A single dose of 1 ml/kg iodopyracet (Umbradil) 50 % or diatrizoate (Urografin) 76 % seems to be tolerated in dogs when injected above the occluded descending aorta but even a 50 % concentration of sodium acetrizoate

Table

Result of 56 aortographies above an occluded aorta in dogs

No of dogs	Contrast media	ml/kg contrast medium per injection	Iodine g/ml	Injection equipment and injection *pressure*	No of injections in non occluded aorta (asc.)	No of injections in occluded aorta (desc.)	Pareses
8	Iodopyracet (Umbradil) 70 %	1	0.35	Pressure syringe ad modum Jonsson	—	1	3
20	Iodopyracet (Umbradil) 50 %	1	0.25	»	—	1	0
1	Sodium acetrizoate (Urokon) 70 %	1	0.46	»	—	1	1
2	Sodium acetrizoate (Urokon) 50 %	1.5	0.33	»	—	1	1
7	Sodium acetrizoate (Urokon) 50 %	1	0.33	»	—	1	1
1	*Sodium and methylglucamine* diatrizoate (Urografin) 76 %	1	*0.37*	*Pressure syringe* ad modum Gidlund 4 kg	—	[illegible]	1
2	Sodium and methylglucamine diatrizoate (Urografin) 76 %	1	0.37	»	2	1	1
15	Sodium and methylglucamine diatrizoate (Urografin) 76 %	1	0.37		1	1	0

was 10 to 100 times greater than after sodium diatrizoate 50 % when the blood brain barrier has been damaged. Diagnostic doses of contrast medium do not produce any marked effects upon the EEG. In high doses, *however*, sodium acetrizoate exerts a greater influence upon the EEG than iodopyracet, diatrizoate, and diprotrizoate.

READ et coll. (1959) noted a red blood cell aggregation in the vessels following injections of diatrizoate, an effect that could be prevented by low molecular weight dextran (BERNSTEIN 1961).

The *spinal cord* is as sensitive to the toxicity of contrast media as the brain. MARGOLIS et coll. (1959) were of the opinion that the best method of test... the toxic effect of different contrast media was on the spinal cord of the d... The cord is supplied through the spinal arteries from the dorsal segment... arteries of the aorta. These authors reported that as regards an action on the cord acetrizoate was by far the most toxic, iodopyracet and diprotrizoate less toxic, and diatrizoate the least toxic medium.

An experimental investigation was performed in collaboration with B. Nordenstrom to ascertain the maximal safe amount of contrast media that may be injected into the aorta when the flow is directed towards the dorsal spinal arteries. The directing of the contrast medium to these vessels may be

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produces complications It is remarkable that the administration of the least toxic medium, diatrizoate, by two injections above the occluded descending aorta, or by two injections into the ascending aorta without occlusion followed by one injection above the occluded descending aorta, produces paresis

All the experimental investigations would thus appear to lead to the same conclusions

Sodium acetrizoate is *the most toxic substance to the blood brain barrier* peripheral vessels, vasomotor centre of the brain and spinal cord We also know from other experiments that it is the most toxic to the kidneys (LINDGREN 1961)

The diatrizoate media are at present the least toxic VOSSE (1960) suggested that a mixture of sodium and methylglucamine compounds may be less toxic than the pure sodium salt

Iodopyracet and diprotrizoate hold an intermediate position

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SUMMARY

The results of experiments have shown that the contrast media of the diatrizoate group are the least toxic for cerebral angiography although these have a marked effect upon the central nervous system expecially when repeated injections in high concentrations are made into the aorta Not more than one injection should be performed into this vessel above an occlusion

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Experimente zeigen dass Kontrastmittel der Diatrizoat Gruppe am wenigsten schädlich fur die cerebrale Angiographie sind obwohl sie einen merklichen *Einfluss auf das Zentral*nervensystem ausuben besonders wenn sie wiederholt in hoher Konzentration in die Aorta eingespritzt werden Nicht mehr als eine Injektion sollte erfolgen wenn oberhalb eines Aorten-verschlusses injiziert wird

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FROM THE ROENTGEN DEPARTMENT (DIRECTOR PROF H SALINGER) BEILINSON HOSPITAL PETAH TIQVA ISRAEL

COMBINED PHLEBO-PNEUMOGRAM OF THE POSTERIOR CRANIAL FOSSA

by

A Weiss

Expansive lesions of the brain and to a lesser degree infiltrative lesions both of which are not particularly rich in blood vessels are demonstrated in roentgen examinations mainly as a result of the displacement or deformity of the adjacent blood vessels or air filled spaces The branches of the internal carotid artery and the peripherally situated lateral ventricles are comparatively easily displaced As we approach the deeper (more central) areas of the brain the passive mobility of the vessels and air spaces (deep veins and third ventricle) decreases because of their location in a more fixed area (corpus callosum and midbrain) The displacement possibilities decrease still further in the sub tentorial zone In pneumography of this area we are concerned with the fixation of the aqueduct and the fourth ventricle (foramen of Magendie and entrance of the aqueduct into the third ventricle) while in angiography it is the fixation of the straight sinus located in a fold of the tentorium which is of importance Acting on the assumption that in view of the relative lack of mobility of the structures in this area even small changes become diagnostically significant it was decided to study the topographic relations between the aqueduct and the fourth ventricle and those between the great cerebral vein (of Galen) and the straight sinus

The aim of this paper is to describe the normal topographic relation between these structures we have intentionally disregarded their relations with the bones of the skull It appears that this is the first attempt at a simultaneous

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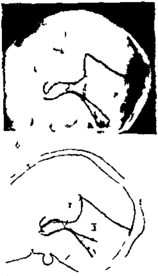


Fig 3 Case 1 A tumour of the Rolandic fossa α 17 distance I = 41 mm distance II = 48 mm

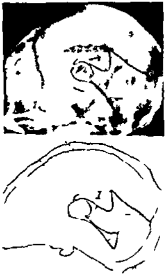


Fig 4 Case 2 Deep parietal tumour α ± 0 distance I – 43 mm distance II 45 mm



Fig 5 Case 3 Brain stem tumour α 12 distance I = 24 mm distance II = 28 mm

ventricle and the aqueduct This method produces what we call a midline phlebo pneumogram (Fig 2)

Fifty roentgenologically normal cases were examined by the method in order to establish the normal appearances The following measurements were taken

1 The acute angle between the direction of the aqueduct and the straight sinus The direction of the aqueduct was determined at its anterior border, before the curve at the level of the lamina quadrigemina The line between the two extremities of the straight sinus was adopted as its direction The acute angle formed by the forward extension of these two lines until they cross was designated alpha (a)

2 The distance separating the entrance of the aqueduct into the third ventricle from the entrance of the great cerebral vein (of Galen) into the straight sinus was measured and designated distance I

3 The shortest distance between the floor of the fourth ventricle and the straight sinus was measured and designated distance II

All these three values are shown in Fig 2 indicated as a. and I and II. respectively



Fig 1 Midline structures of the brain

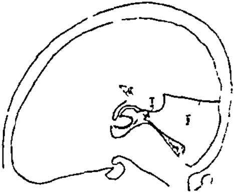


Fig 2 Schematic illustration of normal m[illegible] phlebo pneumogram α 35 distance I [illegible] mm distance II = 45 mm

angiopneumographic evaluation of the posterior cranial fossa The studies were made in the venous phase of the angiogram

Anatomy The structures under investigation are situated in the midline of the posterior cranial fossa (Fig 1) The fourth ventricle and the aqueduct pass along the posterior border of the pons in the direction of the third ventricle before entering the latter the aqueduct describes a sharp curve at the level of the lamina quadrigemina

The straight sinus is situated in the midline at the angle between the tentorium and the falx, it starts at the entrance of the great cerebral vein (of Galen at the level of the splenium of the corpus callosum and enters the transverse sinus posteriorly at the level of the internal occipital protuberance Its course is rigidly fixed and it can only with difficulty deviate Between these two structures, the aqueduct and the fourth ventricle on the one side and the straight sinus on the other side, lies the cerebellum According to RUGGIERO (1957) the direction of the aqueduct in normal encephalograms is almost constant

Method

We have devised a method which demonstrates simultaneously all these structures This calls for two separate examinations (1) encephalography to show the fourth ventricle and the aqueduct, (2) cerebral angiography to demonstrate the deep veins and the straight sinus in a late venous phase (the deep phlebogram) As it is technically not feasible to perform both at the same time, we have elected to transcribe graphically the phlebograms of the fourth



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Table

Minimal maximal and average values obtained in measurements in 50 cases in normal lateral phlebo pneumograms of midline posterior cranial fossa

Aqueduct sinus rectus angle (α)				Distance aqueduct sinus rectus (I) in mm				Distance fourth ventricle sinus rectus (II) in mm			
Min	Average	Max	Range	Min	Average	Max	Range	Min	Average	Max	Range
27	34	41	14	21	46	35	14	38	46	55	17

The minimal, maximal and average values obtained in these measurements are given in the Table, from which appears the range of normal variation. Analysis of the values indicates that the midline phlebo pneumogram has a typical pattern in normal cases, with a small range of deviations The angle alpha varies by ± 7 from the average value, and the distances I and II each deviate from between ± 7 to 8 mm We believe that these deviations are caused by minor differences in the individual structure of skulls

After some experience with the readings of normal films had been gained, the diagnostic study of abnormal cases was undertaken A complete study of pathologic phlebo pneumography will be published at a later date Three illustrative cases are presented in this preliminary report

Case reports

Case 1 A tumour of the fossa of Roland (Fig 3) The phlebo-pneumogram showed marked changes due to a backward displacement of the anterior point of origin of the straight sinus by a tumour The angle alpha was significantly reduced (it measured only 17) and at the same time distance I was considerably increased as a result of separation of the straight sinus from the aqueduct The value of distance I was almost equal to that of II

Case 2 A large deep parietal tumour (Fig 4) The phlebo-pneumogram again revealed marked displacement of the anterior origin of the sinus so that the directions of the aqueduct and straight sinus were parallel and did not form an angle Distances I and II are almost equal in this case

Case 3 A brain stem tumour (Fig 5) The phlebo pneumogram revealed a decrease in the angle alpha (12) by a posterior displacement of the aqueduct and the fourth ventricle This case was different from Cases 1 and 2 as the values of the distances I and II were both decreased due to the narrowing of the distance between the aqueduct and the straight sinus

SUMMARY

A graphic correlation of simultaneous evaluation of cerebral [illegible] graphy termed midline phlebo-pneumogram of the p[illegible] [illegible]bography a [illegible] fossa is de[illegible] normal values are discussed and three abnormal [illegible]

ZUSAMMENFASSUNG

Eine graphische Korrelation einer gleichzeitigen Bewertung der zerebralen Phlebographie und der Pneumographie die man Mittellinie Phlebo-Pneumogram der Fossa cranialis posterior nennen kann wird beschrieben Die normalen Verhaltnisse werden diskutiert und 3 anormale Falle werden vorgelegt

RÉSUMÉ

L auteur présente une corrélation graphique qu il appelle phlebo pneumogramme de la ligne mediane de la fosse postérieure et qui permet d interpréter simultanément la phlébographie cerébrale et la pneumographie Il en étudie les valeurs normales et présente trois cas pathologiques

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FROM THE ROENTGEN DEPARTMENT (DIRECTOR PROF ERIK LINDGREN) SERAFIMER LASARETTET, STOCKHOLM, SWEDEN

ANATOMIC CASTS MADE BY A CORROSION METHOD

by

GUNNAR WESTBERG

Modern methods of roentgen investigation now contribute to a detailed study of the living anatomy, and anatomic casts of the organs and other structures of the human body are of particular value in its appreciation This is well shown in the study of the anatomy of the brain in which the preparation may be directly compared with the appearances evident in the films Materials such as metals, waxes and vegetable gums have been in use to date, although for various reasons they possess considerable disadvantages They often deform the organs or undergo alteration after hardening, the casts are therefore both clumsy and fragile and fail to depict the true anatomical conditions

A step forward in the art of preparation of detailed anatomic casts was heralded with the introduction of the so called cold polymerizing plastics These substances are unaffected by strong acids and alkalis so that the soft tissue may be easily removed after the casting material has hardened The types of plastics ordinarily used are however, not ideal The amounts of accelerator and catalyst that must be added to the fluid monomer in order to induce its hardening at room temperature are small and therefore difficult to control exactly The plastic may harden in the syringe during the injection or fail to set at all, and, in addition, hardening produces a certain change in volume

The author was fortunate in alighting upon a metacryl resin type of plastic that appeared to be free of the disadvantages mentioned It is commonly used in dentistry and readily available through the dental supply houses Several brands are available, and a product known as 3—60 Quick (made by Hull



Cast of intracranial vessels and cisterns

Dentaire Ivoclair, Schaan, Liechtenstein) has been found satisfactory The monomer is a fluid and the preformed polymer is supplied in the form of a very fine powder, the accelerator has already been added to the monomer and the catalyst to the polymer Equal amounts by weight of fluid and powder rapidly produce a translucent plastic mass for injection into cavities or vessels The medium is not especially sensitive to moderate variations in mixing conditions and is therefore easy to use The volume of the plastic mass does not significantly shrink on hardening

The powder may be mixed with dyes such as cadmium red and Paris blue, and rendered roentgen opaque by the addition of barium sulphate A particular advantage lies in the fact that the instruments, such as syringes used for the injection of the plastic may easily be cleaned The speed of the hardening of the plastic can be readily controlled and a preparation consisting of equal parts of fluid and powder can be injected in about five minutes it completely hardens in about half an hour It is not especially sensitive to variations in temperature during hardening, but in the case of larger casts the covering of the preparation with ordinary cold tap water may prove of advantage

The figure depicts a cast of the intracranial vessels and cisterns The fourth ventricle aqueduct and third ventricle were also filled in this instance

The cast was prepared in the following way Catheters were inserted into the internal carotid and vertebral arteries the medium being injected into

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FROM THE ROENTGEN DEPARTMENT (DIRECTOR PROF ERIK LINDGREN), SERAFIMER-LASARETTET STOCKHOLM SWEDEN

THE RECURRENT ARTERY OF HEUBNER AND THE ARTERIES OF THE CENTRAL GANGLIA

by

GUNNAR WESTBERG

The so-called lenticulo striate arteries have received little or no attention in the textbooks on cerebral angiography They are roughly and inaccurately illustrated and no uniform terminology for the different arteries exists Some authors use the term lenticulo striate arteries, while others term them strio thalamic arteries The present writer considers they should be called just the arteries of the central ganglia', especially since they often vary in their areas of distribution

ANDERSEN was the first to draw attention to the roentgenologic aspect of the anatomy of these arteries and based his study on angiographic material He described the lenticulo striate arteries as almost always arising from the middle cerebral artery and then branching within an area of 13 to 15 mm in length Only in one exceptional case did they arise from the anterior cerebral artery This is not in conformity with the anatomical work of HEUBNER and later authors such as BEEVOR AITKEN SHELLSHEAR CRITCHLEY and ABBIE The work of all these latter conveys the impression that the recurrent artery of Heubner which arises from the anterior cerebral artery is a very important and constant vessel for the blood supply to the central ganglia This artery supplies mainly the lower portion of the head of the caudate nucleus, the lower anterior portion of the internal capsule and a portion of the lentiform nucleus Arteries from the middle cerebral artery supply chiefly the upper frontal and

all four arteries, which were then clamped The cisterns were then filled with the plastic medium through a catheter inserted into the cervical subarachnoidal space, access to which was gained by removal of the bodies of a few cervical vertebrae, so that the catheter could be inserted and a peridural ligature applied The preparation, after hardening, was removed by the severance of the spinal cord through a suboccipital opening and by cutting the intracranial attachments

The corrosion process was performed as follows The specimen was left in a concentrated sodium hydroxide solution for about two days, the solution was replenished as necessary during the period so that its strength was maintained The soap formed by the interaction with the tissue fat was removed by washing the specimen in slow running water for about 24 hours

SUMMARY

A method of preparing corrosion casts of the cerebral vessels and cisterns from a special plastic resin is described in detail

ZUSAMMENFASSUNG

Eine Methode zur Anfertigung von Korrosionsausgussen der Gehirngefasse und Zysternen mittels eines besonderen Kunstharzstoffes wird im einzelnen beschrieben

RÉSUMÉ

L auteur décrit en détail une méthode (de corrosion) de préparation de moulages des vaisseaux cérébraux et des citernes par injection d une résine plastique spéciale

FROM THE ROENTGEN DEPARTMENT (DIRECTOR PROF ERIK LINDGREN), SERAFIMER LASARETTET, STOCKHOLM SWEDEN

THE RECURRENT ARTERY OF HEUBNER AND THE ARTERIES OF THE CENTRAL GANGLIA

by

GUNNAR WESTBERG

The so-called lenticulo striate arteries have received little or no attention in the textbooks on cerebral angiography They are roughly and inaccurately illustrated and no uniform terminology for the different arteries exists Some authors use the term lenticulo-striate arteries while others term them strio-thalamic arteries The present writer considers they should be called just the arteries of the central ganglia especially since they often vary in their areas of distribution

ANDERSEN was the first to draw attention to the roentgenologic aspect of the anatomy of these arteries and based his study on angiographic material He described the lenticulo-striate arteries as almost always arising from the middle cerebral artery and then branching within an area of 13 to 15 mm in length. Only in one exceptional case did they arise from the anterior cerebral artery This is not in conformity with the anatomical work of HEUBNER and later authors such as BEEVOR, AITKEN, SHELLSHEAR, CRITCHLEY and ABBIE The work of all these latter conveys the impression that the recurrent artery of Heubner which arises from the anterior cerebral artery is a very important and constant vessel for the blood supply to the central ganglia This artery supplies mainly the lower portion of the head of the caudate nucleus the lower anterior portion of the internal capsule and a portion of the lentiform nuc Arteries from the middle cerebral artery supply chiefly the upper frontal

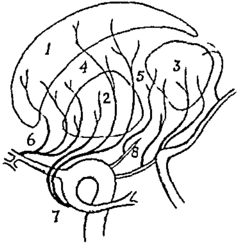


Fig 1 Diagram of the central ganglia with their common blood supply 1 — caudate nucleus 2 — lentiform nucleus 3 — thalamus 4 — internal capsule (anterior limb) 5 — internal capsule (posterior limb) 6 — Heubner s artery arising from the anterior cerebral artery 7 — arteries arising from the middle cerebral artery 8 — anterior choroidal artery

medial portions of the caudate nucleus, parts of the lenticular nucleus and both anterior and posterior limbs of the internal capsule (Fig 1)

The following method was adopted for the study of Heubner s artery in more detail and its roentgenologic significance in the assessment of the arteries to the central ganglia

1 A cold polymerizing plastic mass was injected in situ into the intracranial arteries in cadavers

2 The plastic mass in some instances was roentgen opaque, and films were obtained in a p and lateral projections

3 After removal of the brain from the skull, the arteries of the central ganglia could be traced from their origin to their site of entry in the anterior perforated substance

4 After corrosion, the remainder of their course could be studied

The present material comprises 34 corrosion specimens Heubner s artery was present in all cases except one, in which the anterior cerebral artery was absent and in which branches from the middle cerebral artery and the anterior choroidal artery served in its place A duplication of Heubner s artery was present in another case The following observations were made in the remaining 32 cases

Heubner s artery arose from the superior aspect of the anterior cerebral artery near the communicating artery, it then passed in a retrograde direction close to the anterior cerebral artery, often in a tortuous course and located above, sometimes in front of and occasionally behind the anterior cerebral artery Its ramifications lay at the level of the internal carotid bifurcation or lateral to it, the branches then passing upwards into the anterior perforated substance and within the brain pursuing first a lateral and then a medial course It is obvious from these anatomical conditions that the main stem of

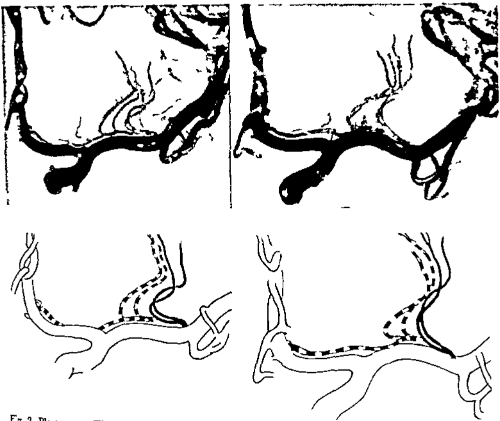


Fig 2 Plastic cast The carotid bifurcation and its branches in two somewhat different projections The branches from Heubner s artery (interrupted line) may appear angiographically to arise from the middle cerebral artery

this vessel must be often difficult and sometimes even impossible to identify in clinical angiography, and therefore its branches may be easily mistaken for branches from the middle cerebral artery (Partial superimposition of Heubner s artery on the margins of the vessels forming the carotid bifurcation may possibly convey the impression of vascular disease)

Arteries to the central ganglia arising from the middle cerebral artery were present in all cases, and in 32 of them the vessels sprang from the superior posterior aspect of the middle cerebral artery, fairly far laterally The vessels usually had one, two or three main branches arising close to each other with or without a short common trunk Vessels in two cases arose from a trunk that took its origin from the posterior parietal artery and in one of the cases an additional branch arose from one of the other Sylvian vessels in a third case two trunks one arising laterally and the other one closer to the bifurcation, were present The main branches in all 34 cases first passed medially and backwards in relation to the middle cerebral artery and roughly parallel to it

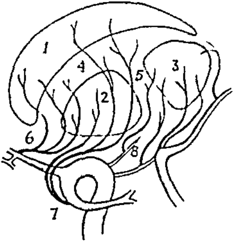


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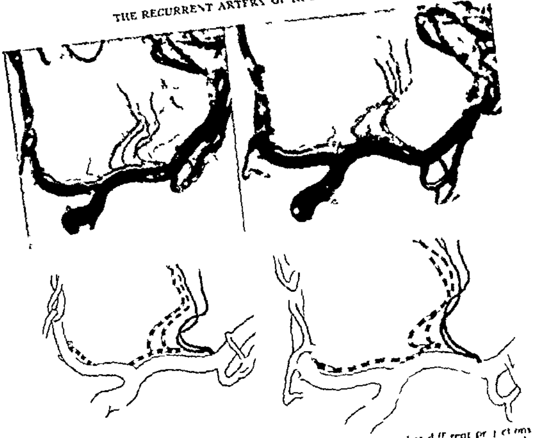


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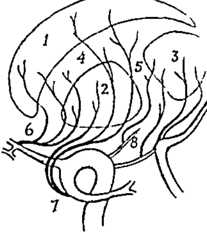


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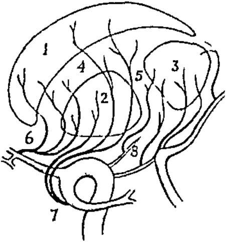


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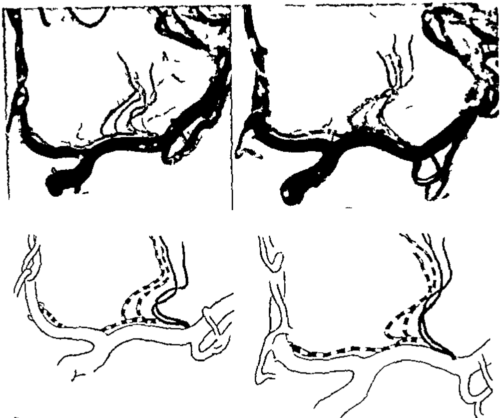


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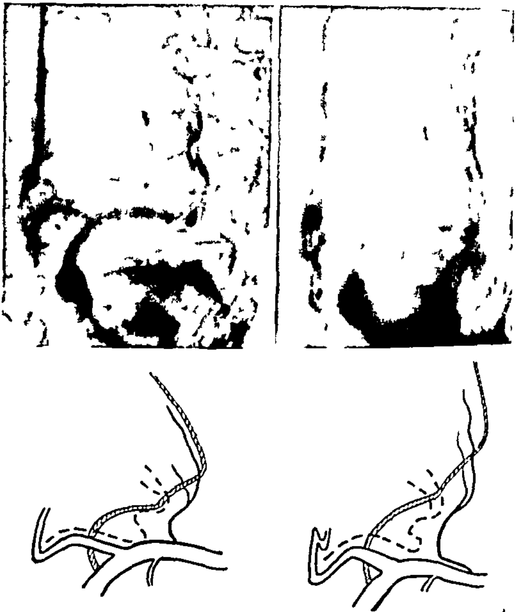


Fig 3 Normal angiograms of the carotid bifurcation and its branches. Heubner's artery is particularly well demonstrated in its entire course (interrupted line), branch from the middle cerebral artery (full line), anterior chorodial artery (striped line)

these segments varied in length and sometimes reached as far as the carotid bifurcation or even beyond it so that Heubner's artery by comparison was short. The vessels then ramified, turned upwards and laterally to enter the anterior perforated substance, they continued their lateral course within the brain substance and then turned medially

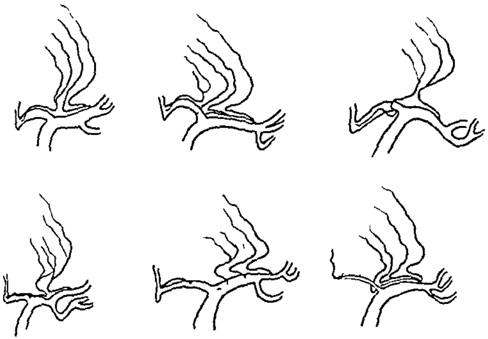


Fig 4 Common variations of arteries to the central ganglia

The half axial view is often the most advantageous for the roentgenographic demonstration of the arteries (Fig 3) The intracranial arrangement is such that branches from Heubner's artery lie more medially and those from the middle cerebral artery more laterally in the anteroposterior projections Partial superimposition of branches of both systems is inevitable, in the lateral projection they have a fanlike appearance, but are often identified only with difficulty, because other arteries, mainly of the Sylvian group interfere with their definition

The description of the more minute branches from the carotid bifurcation not demonstrable by present day angiographic methods is beyond the scope of this paper

SUMMARY

The anatomy of the arteries to the central ganglia has been studied in 34 corrosion specimens of the anterior and middle cerebral arteries and compared with their angiographic appearances in clinical and autopsy cases Earlier roentgenographic descriptions are discussed

ZUSAMMENFASSUNG

Die Anatomie der Arterien der Basalganglien wurde anhand von 34 Korrosionsausgussen der Arteria cerebralis anterior und media studiert und mit den angiographischen Bildern und Sektionsfaten verglichen Fruhere angiographische Befunde wurden einem Vergleich unterzogen

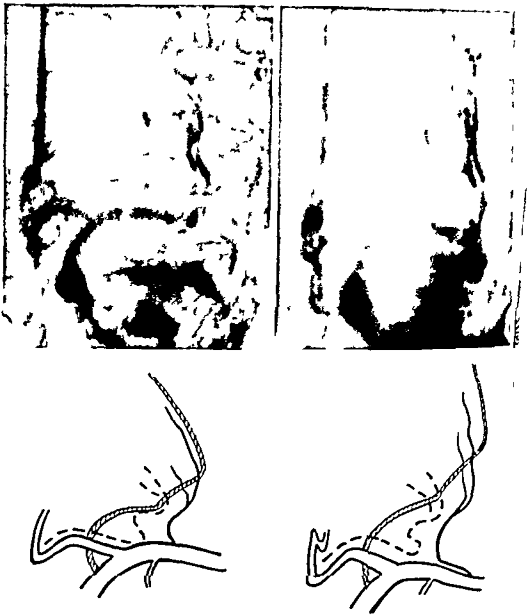


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AUS DER RONTGENABTEILUNG (LEITER PROF DR K DECKER) DER NERVENKLINIK (DIREKTOR PROF DR K KOLLE) DER UNIVERSITAT MUNCHEN, DEUTSCHLAND

NEURORADIOLOGISCHE UNTERSUCHUNGEN BEI SAUGLINGEN UND KLEINKINDERN

von

O WIEDENMANN

Bei Sauglingen und Kleinkindern ist die Durchfuhrung neuroradiologischer Untersuchungen eng an die Probleme und Methoden der Anaesthesie gebunden Diese kleinen Kinder mit Erkrankungen des Zentralnervensystems sind oft schwer in ihrer korperlichen Entwicklung gestort und leichter als bei anderen Patienten treten bei ihnen im Laufe der Untersuchung Storungen der Atmung und des Kreislaufes auf Kinder unter 3 Jahren werden deshalb grundsatzlich in einer Intubationsnarkose untersucht Bei großeren Kindern wird es vom korperlichen Zustand und der Art der Untersuchung abhangig gemacht, ob man sich auf eine Tropfnarkose und Maskenbeatmung beschrankt oder intubiert Eine Encephalographie mit Kontrolle des Fullungsvorganges wird auch bei großeren Kindern fast immer in Intubationsnarkose durchgefuhrt Alle Kinder werden in Vollnarkose mit einem Fluothane Lachgasgemisch untersucht Fur die meisten Untersuchungen ist eine Narkose von einer halben bis einer Stunde Dauer notwendig Bei mittlerer Narkosetiefe kann der Untersucher ungestort von Schmerz und Hustenreflexen des Patienten arbeiten Es zeigt am besten die folgende Übersicht uber unsere eigenen Untersuchungen an Kindern unter 6 Jahren wie unter dem Einfluß der verbesserten Anaesthesiemethoden die Zahl der untersuchten Sauglinge zunimmt

Die Encephalographie von Sauglingen und Kleinkindern in sitzender Position ist unserer Ansicht nach immer etwas schwierig Es wird in dieser Haltung auch ein Blutdruckabfall begunstigt Wir fuhren deshalb in Anlehnung an die Methode LENZI s die Encephalographie in Bauchlage durch Ein Lagerungs

RÉSUMÉ

L'anatomie des artères des noyaux gris centraux a été étudiée sur 31 pièces de corrosion des artères cérébrales antérieure et moyenne et a été comparée avec leur aspect angiographique clinique et post mortem. L'auteur examine les descriptions radiologiques publiées auparavant.

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AUS DER RÖNTGENABTEILUNG (LEITER: PROF. DR. K. DECKER) DER NERVENKLINIK
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O WIEDENMANN

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Die Encephalographie von Säuglingen und Kleinkindern in sitzender Position ist unserer Ansicht nach immer etwas schwierig Es wird in dieser Haltung auch ein Blutdruckabfall begünstigt Wir führen deshalb in Anlehnung an die Methode LENZI s die Encephalographie in Bauchlage durch Ein Lagerungs



a b

Abb. 1. Encephalogramm bei einem zweijährigen Kind in Intubationsnarkose in Bauchlage. Nach Injektion von 15 ml Luft gute Darstellung von 4. Ventrikel, Aquädukt, 3. Ventrikel, den Seitenventrikeln, einem Teil der basalen Zisternen und den Subarachnoidalräumen über den Hemisphären. b) Großes Subduralhaematom über der rechten Hemisphäre bei einem 3 Monate alten Säugling

	1959	1960	1961 bis zum [illegible] August
Karotis-Angiographie	63 (13)	67 (23)	54 (30)
Vertebralis-Angiographie	4	1	1
Encephalographie	40 (9)	63 (18)	56 (16)
VP und Font. P.	4 (4)	4 (4)	4 ([illegible])
Myelographie positiv	1	2	4 (2)
Myelographie Gas	—		1 (1)
	112	137	1[illegible]0
Davon Säuglinge	([illegible]6)	(45)	(51)

kissen vom Typ „Flexicast" wird zum Fixieren des Kindes benutzt und dient gleichzeitig als Kasettenhalter für die Aufnahmen im seitlichen Strahlengang. Es lassen sich auf diese Weise Einzelheiten des Ventrikelsystems und auch der inneren und basalen Hirnzisternen gut darstellen (Abb. 1a).

Von den diagnostischen Problemen, die es bei Säuglingen und Kleinkindern gibt, sollen zwei herausgegriffen werden: (1) die subduralen Haematome, (2) die Veränderungen des Gefäßlumens.

Das typische Subduralhaematom ist angiographisch leicht zu diagnostizieren (Abb. 1b). Manchmal zeigen die Bilder im sagittalen Strahlengang keine Auffälligkeiten. Erst im Seitenbild erkennt man frontal und parietal aber

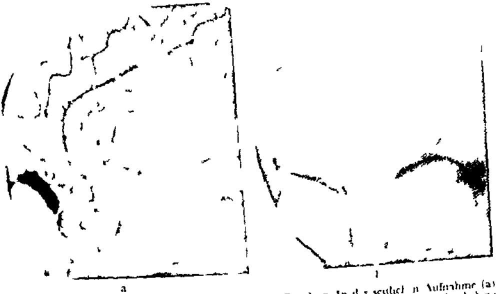


Abb 3 Subduralhamatom bei einem 11 Monate alten Saugling In der seitlichen Aufnahme (a) und in der gedrehten Aufnahme (b) ist die Abdrängung der Randgefaße von der Kalotte deutlich zu erkennen.

drangte Gefaße Auch in Aufnahmen mit gedrehtem Kopf wird der Befund deutlich Aber auch das scheinbar typische Bild einer subduralen Flussigkeits ansammlung kann Anlaß fur einen Irrtum sein So findet man bei einem 11 Monate alten Kind (Abb 2) mit zerebralen Krampfanfallen im Karotisangio-gramm eine starke Abdrangung der Gefaße von der Kalotte frontal bis zur großen Fontanelle Bei der Fontanellenpunktion war aber nur reiner Liquor zu gewinnen Das Encephalogramm (Abb 2b) zeigt nun daß das Frontalhirn nicht der Kalotte anliegt und dass der Subarachnoidalraum weit ist

Man gewinnt aus Abb 3 den Eindruck einer Hypoplasie oder Atrophie des Stirnhirns Den genauen anatomischen Befund wissen wir nicht das Kind lebt mit einem korperlichen und geistigen Entwicklungsruckstand

Ein ahnlicher encephalographischer Befund eines Hydrocephalus internus kann aber auch vorgetauscht werden, wenn Luft partiell im Subarachnoidal raum und im Subduralraum liegt (Abb 4) Auffallig ist die große Beweglich keit des Gehirns bei Lageanderungen

Die diagnostische Deutung der Einengung des Lumens der intrakraniellen Arterien bei Sauglingen und Kleinkindern stellt ein anderes diagnostisches Problem dar Dieser Befund lokalisiert sich meist in den Bereich der Basal zisternen Ein Grund kann die Streckung oder Ummauerung der Gefaße durch einen basalen Tumor sein Die durch den Tumor bedingten Ver lagerungserscheinungen brauchen hierbei nicht sehr ausgepragt zu sein (Abb 5a)



a b

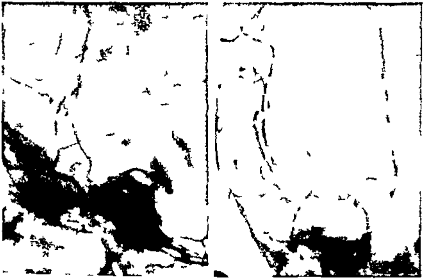
Abb. 1. Encephalogramm bei einem zweijährigen Kind in Intubationsnarkose in Bauchla... Injektion von 15 ml Luft: gute Darstellung von 4. Ventrikel, Aquädukt, 3. Ventrikel, den Se... trikeln, einem Teil der basalen Zisternen und den Subarachnoidalräumen über den Hemi... b. Großes Subduralhaematom über der rechten Hemisphäre bei einem 3 Monate alten Säugling

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V. P. und Font. P.	4 (4)	4 (4)	4 (?)
Myelographie positive	1	2	4 (?)
Myelographie Gas	—	—	1 (1)
	112	137	120
Davon Säuglinge	(26)	(45)	(51)

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a b

Abb 5 a) Einengung der intrakraniellen A carotis interna bei einem 7 Monate alten Kind mit einem Optikusgliom b) Starke Einengung des Carotissiphons in seinen oberen Abschnitten bei einem einjährigen Kind mit einer Influenzameningitis

macht und finden sie seltener bei Erwachsenen Sie scheinen neben einem Abszess oder einem subduralen Erguß eine Ursache fokaler Störungen von Seiten des Gehirns zu sein

Ein weiterer Fall war in besonderer Art schwierig zu deuten Ein Mädchen von 4 Jahren erkrankte mit den Zeichen einer Steigerung des intrakraniellen Druckes eine Stauungspapille von 3 Dioptrien beiderseits wurde festgestellt Die Karotisangiographie zeigt eine Verschmählerung des Gefäßlumens vorwiegend im Bereich der A cerebri media (Abb 6b) Alle weiteren Untersuchungen einschließlich Encephalographie und Liquordiagnostik waren negativ Das Mädchen gesundete nach einigen Wochen und es bleibt unklar welche Erkrankung vorlag Es bleibt auch unklar in welcher Beziehung der angiographische Befund zu der Erkrankung war ob er sie verursachte oder nur Folgeerscheinung war

Es darf abschließend gefolgert werden daß wir bei der Untersuchung von Säuglingen und Kleinkindern im Röntgenbild noch manche Befunde wahrnehmen, deren morphologische Bedeutung und deren Einfluß auf die klinisch fassbaren Krankheitserscheinungen noch unklar ist

ZUSAMMENFASSUNG

Es wird auf die Bedeutung moderner Anaesthesie Methoden für die neuroradiologische Untersuchung von Säuglingen und Kleinkindern hingewiesen Es ist hierdurch möglich geworden bei entsprechender klinischen Indikation praktisch alle erforderlichen neuroradiolo-

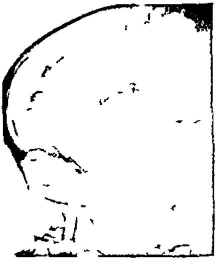


Abb. 3



Abb. 4a

Abb. 3. Bei einem einjährigen Kind mit dem angiographischen Bild eines frontalen subduralen Flüssigkeitsergusses zeigt das Encephalogramm einen stark erweiterten Subarachnoidalraum, wahrscheinlich auf Grund einer Hypoplasie oder einer atrophischen Läsion des Stirnhirns.

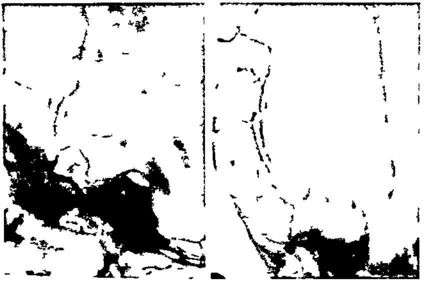
Abb. 4. Encephalographie bei einem 11 Monate alten Kind. a) Ein Teil der Luft ist in den Subduralraum, ein Teil in den Subarachnoidalraum gelangt. Es kann hierdurch ähnlich wie bei Abb. 3 der Eindruck einer frontalen atrophischen Läsion des Gehirns entstehen. b) In Stirnlage fallen die dorsalen Abschnitte des Großhirns nach rostral.



Abb. 4b

Nicht selten findet man verengte Gefäße bei einer Meningitis. Das Angiogramm wird meistens angefertigt, weil Herdsymptome wie eine Hemiplegie oder Anfälle vom Jacksontyp auftreten. Ein erstes Beispiel zeigt bei einer Influenza-Meningitis schwere angiographische Veränderungen, die an einen partiellen Verschluß der A. carotis im Siphonbereich erinnern (Abb. 5b). Die weiteren Untersuchungen zeigten einen kommunizierenden Hydrocephalus internus, aber nicht die nach den klinischen Erscheinungen vermutete Raumbeschränkung, etwa einen Abszess.

In einem anderen Beispiel erkennt man die Einengung der basalen Gefäße bei einer tuberkulösen Meningitis (Abb. 6a). Auch bei kindlichen Meningitiden mit anderen Erregern haben wir ähnliche Beobachtungen am Gefäßsystem ge-



a b

Abb. 6 a) Einengung der intrakraniellen A. carotis interna bei einem Monate alten Kind mit einem Optikusgliom b) Starke Einengung des Carotissiphons in seinen oberen Abschnitten bei einem einjährigen Kind mit einer Influenzameningitis.

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a b

Abb. 6. a) Einengung des Gefäßlumens im Bereich des Carotissiphons, der A. chorioidalis anterior und der Mediagruppe bei einem dreijährigen Kind mit einer tuberkulösen Meningitis. b) Einengung des Hauptstammes und einzelner Äste der A. cerebri media bei einem fünfjährigen Kind mit einer Stauungspapille unbekannter Ursache

gischen Untersuchungsmethoden schon in den ersten Lebenswochen anzuwenden. Es werden hierbei eine Reihe von Befunden erhoben, die uns von den Beobachtungen bei Erwachsenen hier weniger geläufig sind und deren Deutung noch Schwierigkeiten macht. Dies wird an einigen Beispielen bei der Differentialdiagnostik der Subduralergüsse und der Einengung des Lumens der intrakraniellen Arterien erläutert.

SUMMARY

The value of modern methods of anaesthesia as applicable to babies and infants is emphasized. Where clinically indicated these newer procedures permit a complete neuroradiological examination to be performed during the first weeks of life. A number of unfamiliar findings that are different from the appearances observed in adults and the significance of which is still obscure are reported; these include subdural effusions and narrowing of the intracranial arteries. The differential diagnosis is discussed.

RÉSUMÉ

L'auteur souligne l'intérêt des méthodes modernes d'anesthésie pour les examens neuroradiologiques des nourrissons et des jeunes enfants. Elles permettent de pratiquer dès les premières semaines de la vie pratiquement toutes les méthodes d'examen neuroradiologique nécessaires en fonction des indications cliniques. On a ainsi constaté toute une série de signes auxquels nous sommes moins accoutumés qu'à la séméiologie des adultes et dont l'interprétation *présente encore des difficultés. Ceci est illustré par quelques exemples concernant le* diagnostic différentiel des épanchements sous-duraux et les rétrécissements de la lumière des artères intracraniennes.

FROM THE ROENTGEN LABORATORY (DIRECTOR PROF B G ZIEDSES DES PLANTES)
UNIVERSITY OF AMSTERDAM, HOLLAND

APPLICATION OF THE ROENTGENOGRAPHIC SUBTRACTION METHOD IN NEURORADIOLOGY

by

B G Ziedses des Plantes

The object of the subtraction method is to produce a separate image of the difference between two roentgenograms obtained under similar conditions and is effected by covering one roentgenogram with a diapositive print of the other.

In carotid angiography, for instance, a conventional roentgenogram of the skull and one or more angiograms are obtained in exactly the same position. A diapositive print of the conventional roentgenogram and in the same size is then made on a normal photographic film, this film is exposed and developed in such a way that its contrast is as it were inversely that of the roentgenogram. If the roentgenogram is covered with this diapositive print the result will be that the image of the skull is completely blotted out but if the angiogram is covered with the diapositive only the contrast medium in the vessels will be evident.

A final print of the superimposed films will be useful and will depict the filled vessels as dark structures against a light background. The contrasts outside the image of the contrast medium being very low, the final print may be made on a material of high contrast. The different stages of the procedure are shown in Fig 1.

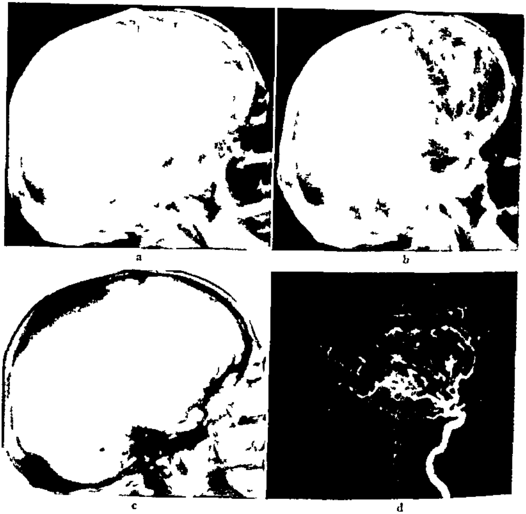




Fig 1 Principle of the subtraction method
a) Conventional roentgenogram of the skull
b) Angiogram and c) diapositive print of (a)
d) Result of covering the angiogram with the diapositive e) Print of the superimposed film



Fig 2 Traumatic carotid cavernous fistula a) Angiogram b) Result of subtraction

The subtraction method may be useful in carotid angiography The application of the method is not essential in the examination of all brain tumors but in some special fields it may be of great value

The result in a traumatic carotid cavernous fistula in a female, aged 66 who, following a head injury two months previously, had developed left exophthalmus with mild venous congestion followed by venous congestion on the right side is shown in Fig 2 No obvious pulsations but a loud systolic bruit was audible over the whole calvarium Fig 2a is a harmonized internal carotid angiogram made 1 sec after the beginning of the injection the subtraction print (b) clearly demonstrates the filling of the different venous outlets

Fig 3a is a common carotid angiogram in a case of brain tumor in a female aged 44 who had complained of drumming headaches Slightly choked disks but no obvious neurologic signs were evident The electroencephalogram suggested a fronto temporal lesion The angiogram revealed an abnormal blood supply in the fronto temporal region which was not clearly outlined The Sylvian vessels were displaced backwards and the anterior cerebral artery backwards and to the right The vascular pattern was not definitely that of a glioma or a meningioma The subtraction print clearly shows the borders of a capillary flush and reveals a blood supply from branches of the external carotid artery, it indicates that the lesion is a meningioma Operation (W Luyendijk) disclosed a lateral sphenoidal ridge meningioma

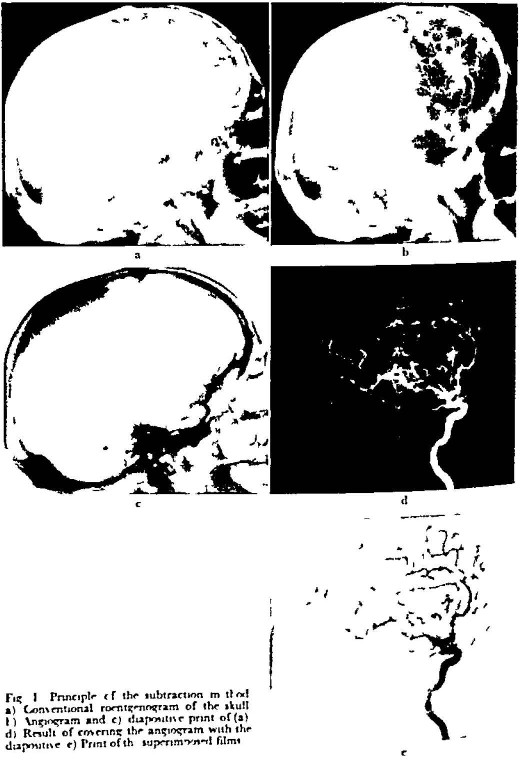


Fig. 1. Principle of the subtraction method. a) Conventional roentgenogram of the skull. b) Angiogram and c) diapositive print of (a). d) Result of covering the angiogram with the diapositive. e) Print of the superimposed films.

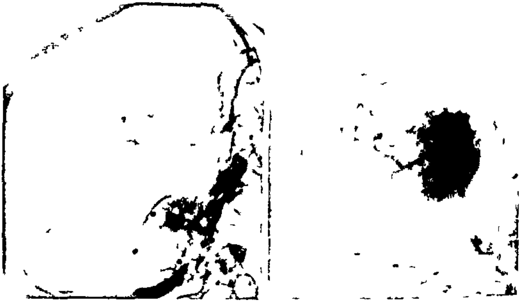


Fig 2. Traumatic carotid-cavernous fistula a Angiogram b Result of subtraction

The subtraction method may be useful in carotid angiography The application of the method is not essential in the examination of all brain tumors but in some special fields it may be of great value

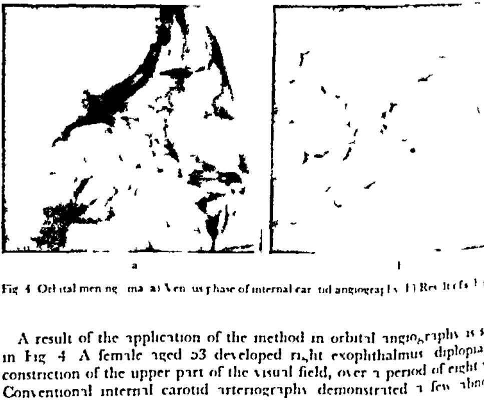
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a b

Fig 3 Meningioma a) Common carotid angiogram b) Result of subtraction



a b

Fig 4 Orbital meningioma a) Venous phase of internal carotid angiography b) Result of subtraction

A result of the application of the method in orbital angiography is shown in Fig 4 A female aged 53 developed right exophthalmus diplopia and constriction of the upper part of the visual field, over a period of eight years Conventional internal carotid arteriography demonstrated a few abnormal

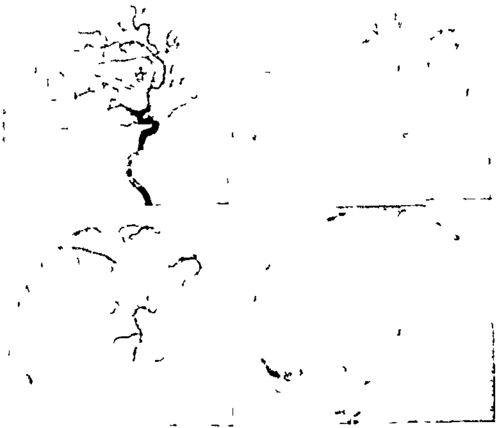


Fig 5 Subtraction prints in a serial angiographic examination of the normal brain circulation

vessels in the orbit Subtraction of the early venous phase revealed the existence of a well defined retrobulbar tumor At operation (A Hangedorn) a meningioma was removed

The method may be applied with advantage in the study of the normal and abnormal circulation of the brain Four subtraction prints of normal angiograms made 3 4 3 5 6, and 10 5 sec after the beginning of the injection are reproduced in Fig 5

It must be emphasized that the subtraction method can never reveal information that does not exist in the original angiogram It is therefore necessary that the density of the roentgenogram is high enough to provide sufficient contrast in the lightest parts of the image

SUMMARY

A short explanation of the principle of the subtraction method is followed by examples of its employment in carotid angiography.

ZUSAMMENFASSUNG

Das Prinzip der Subtraktionsmethode wird erklärt und die praktische Anwendung des Prinzips bei der Carotisangiographie besprochen.

RÉSUMÉ

Le principe de la méthode de soustraction est brièvement expliqué et est illustré par des exemples de son application à l'angiographie carotidienne.

REFERENCE

ZIEDSES DES PLANTES, B. G. Subtraktion. Georg Thieme Verlag, Stuttgart 1961.

FROM THE NATIONAL INSTITUTE OF NEUROLOGICAL DISEASES AND BLINDNESS, NATIONAL INSTITUTES OF HEALTH, PUBLIC HEALTH SERVICE BETHESDA, MARYLAND, AND THE DEPARTMENT OF RADIATION BIOLOGY, UNIVERSITY OF ROCHESTER SCHOOL OF MEDICINE AND DENTISTRY, ROCHESTER, N Y, USA

'RIAF — RADIO IODINATED ANTI FIBRINOGEN ENCEPHALOGRAPHY

Preliminary experiences

by

G DI CHIRO I I SPAR, W F BALE, E J LASKOWSKI RUTH L GOODLAND and W B MATTHEWS

External radioactive localization of cranial lesions is a valuable neuro radiologic method It should be considered more than a 'screening procedure because it yields information which cannot be obtained by any other neuro radiologic technique

The advantages of radioactive localization are

1 Some lesions which escape detection by other radiologic methods are recognized with radioactive isotopes

2 The evidence offered by radioactive isotopes may sometimes corroborate uncertain findings of other neuroradiologic methods,

3 The localization in depth of certain hemispheric suprasylvian lesions in the coronal plane at times a difficult and challenging neuroradiologic problem, may be achieved with the use of isotopes,

4 The multiplicity of some brain lesions which may escape other neuroradiologic examinations, is sometimes shown with isotope scanning

5 The evaluation of the extent of certain lesions may be more accurate with isotope scanning than with other neuroradiologic methods

6 Radioactive localization of cranial lesions is innocuous and causes no discomfort to the patient

Radioactive localization of cranial lesions is, however, still in its infant stage *It is, in our opinion, the new frontier of neuroradiology* *Improvements* are following two lines (1) further development of instrumentation in which significant advantages are continually made, and (2) search for more specific tracers The results in this search have been rather meager The two most useful tracers which today are in competition, are RISA and ^{203}Hg neohydrin Early experiences would tend to indicate that, particularly in the detection of primary glial tumors, ^{203}Hg neohydrin is somewhat better than RISA This is not due to a greater specificity but to the fact that the blood level of ^{203}Hg neohydrin drops rapidly, resulting in a biological background erasing RISA on the other hand holds a sustained blood level for a longer time *Also the* problems of collimation with ^{203}Hg neohydrin are simpler than with ^{131}I because of the lower energy of the peak gamma rays emitted

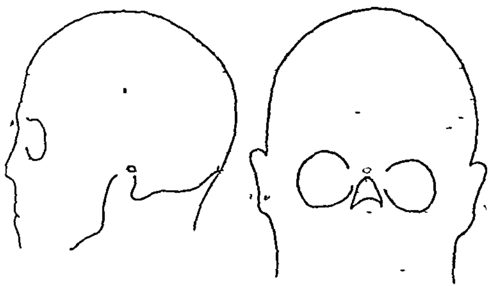
Essentially every tracer used reaches the lesion through a local breakdown of the blood brain barrier which permits accumulation of materials ordinarily excluded The present paper is an account of our first experiences with a tracer which we hope will reach brain lesions by a different mechanism the immunological

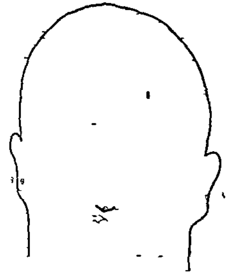
In 1959 DAY PLANINSEK & PRESSMAN showed that fibrinogen and anti fibrin localize in transplanted tumors BALF, SPAR & GOODLAND (1960) demonstrated that ^{131}I labeled antibody to rat fibrin localized with considerable specificity in transplantable Murphy Sturm rat lymphosarcoma SPAR, BALF GOODLAND CASARETT & MICHAELSON, also in 1960 showed that in a few instances radioiodine labeled antibody to dog fibrin preferentially localized within spontaneous tumors of dogs Early in 1960 we began our experiences with human subjects

Antibodies to human fibrinogen are prepared from immunized rabbits and made radioactive by in vitro coupling with ^{131}I This material is injected intravenously into patients whose thyroid has been blocked and who have received a skin test with rabbit globulin The amount of activity injected is about five microcuries per kilogram

Up to the present thirty five cases have been injected with no untoward effect except that one patient complained of chill two hours after the injection of the antibody, followed by a slight elevation of temperature which disappeared in a few hours Of these thirty five cases eighteen were brain scanned following the technique used with RISA and previously reported by one of us (DI CHIRO) Twelve of these eighteen cases had verified lesions three glioblastomas two astrocytomas, two metastatic melanomas three intracranial sarcomas one neuroblastoma one thrombosis of the internal carotid Ten of these lesions were correctly localized with RIAI two (one of the astrocytomas and one of the metastatic melanomas) were not detected Of the twelve cases with verified lesions, seven were also examined with RISA encephalography

A comparison of the differential uptake of a given brain lesion for two





RIAF encephalograms in a verified case of astrocytoma a) Left lateral, b) antero-posterior and c) postero-anterior

tracers with a different biologic half life and a different radiation energy is feasible and reliable This is the case for RISA and ^{203}Hg neohydrin On the other hand comparison by brain scanning of the uptake of two tracers RISA and RIAF both labeled with ^{131}I and presumably with the same biological half life is a difficult task and is subject to limitations After the f

with one of the tracers, one must wait a minimum of three weeks before injecting the new tracer In the meantime, the brain lesion may have changed its features

Granting these limitations, the comparison of RISA encephalography with RIAF encephalography gave the following results The three glioblastomas were detected both with RISA and RIAF, but somewhat better with RISA One of the astrocytomas was missed both with RISA and RIAF The other astrocytoma was nicely outlined by RIAF (see figures), while it had been only questionably shown a month before with RISA The two sarcomas were very clearly demonstrated with RIAF Their detection with RISA encephalography which had been carried out earlier, ten weeks and twenty days respectively had been considered unsatisfactory

It would appear, therefore, that at least for some lesions (sarcomas) there is a fairly specific uptake of the RIAF This tracer might well prove valuable in non tumoral lesions with high deposition of fibrinogen, such as bleedings and thromboses We have noted in cases of thrombophlebitis of the extremities a high uptake of RIAF We are also carrying out comparative studies with RISA and RIAF in the localization of experimental hemorrhagic brain lesions and experimental venous thromboses in dogs Finally it is our plan to investigate the possible improvement of RIAF encephalography by means of epsilon aminocaproic acid This inhibitor of plasminogen activation has in fact proven according to BALE, SPAR, GOODLAND & IZZO, to enhance the localization of antifibrinogen in experimental rat tumors

SUMMARY

Radio-iodinated anti human fibrinogen may be used as a tracer for localizing cranial lesions It seems to show a promising specificity for some of these lesions

ZUSAMMENFASSUNG

Radiumjodgemarktes Antifibrinogen kann zum Aufspüren und Lokalisieren von Schädelverletzungen verwendet werden Es scheint eine vielversprechende Spezifität für einige dieser Läsionen zu haben

RÉSUMÉ

Le fibrinogene anti humain radio-iodé peut etre utilisé comme traceur pour localiser des lésions intracraniennes Il semble présenter pour certaines de ces lésions une spécificité intéressante

Addendum in the proofs

Since the present manuscript was submitted an experiment has been carried out with fifty healthy dogs to compare RISA and RIAF in (1) hemorrhagic brain lesions and (2) venous thromboses in the extremities The hemorrhagic brain lesion was made

by injecting stereotaxically 2 ml of freshly drawn venous blood into the white matter of one hemisphere. Animals were injected with dog RISA or dog RIAF on the second postoperative day and sacrificed on the third, tenth, twelfth or thirteenth day. Others were injected on the seventh and sacrificed on the fourteenth, or injected on the thirty third and sacrificed on the thirty fifth day. At the time of sacrifice (1) intracardiac blood, (2) the lesion (clot) and (3) normal white matter of the opposite hemisphere were collected. Venous thromboses were produced by introducing coils of magnesium aluminum alloy wire into the major surface veins of the thighs. Dog RISA and dog RIAF were injected on the fourteenth or twenty first postoperative day and the animals sacrificed the day after the injection. The grossly thrombosed vessels were collected along with normal veins (opposite extremity) and intracardiac blood. All animals were injected with 50 μC of RISA or RIAF per 30 pounds of body weight and the radioactivity of all the specimens was measured in a scintillation well-counter.

The final data revealed no significant differential uptake between RISA and RIAF in the experimental lesions.

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AUS DER NEURORADIOLOGISCHEN ABTEILUNG (DIREKTOR PROF DR H OESER)
DES STRAHLENINSTITUTS DER FREIEN UNIVERSITÄT BERLIN DEUTSCHLAND

ERGEBNISSE DER HIRNTUMOR-DIAGNOSTIK MIT RADIOAKTIVEN SUBSTANZEN

von

SIGURD WENDE

Die extrakranielle Diagnostik von Hirntumoren mit radioaktivem jodiertem Serum Albumin (RISA) bedeutet einen erheblichen Fortschritt bei der Untersuchung von neurologisch neurochirurgischen Patienten Diese Untersuchungsmethode wird seit ungefähr 1 Jahr in unserer Klinik angewandt und es soll hier über die bisherigen Ergebnisse berichtet werden

Abbildung 1 gibt das Bild unseres Meßplatzes wieder Die besondere Aufhängevorrichtung gestattet eine freie allseitige Beweglichkeit des Meßkopfes so daß jeder gewünschte Punkt auf der Schädelkalotte eingestellt werden kann Die genaue Wiederholungsmessung eines Punktes ist gewährleistet da die Patienten während der Untersuchung eine Badekappe tragen auf der die einzelnen Meßpunkte verzeichnet sind Dabei hat sich das Schema von Mme PLANIOL (Paris) am besten bewährt (Abb 2) Je 5 Meßpunkte frontal rechts und links, je 2 Meßpunkte praecentral rechts und links je 3 Meßpunkte parietal rechts und links, je 3 Meßpunkte temporal rechts und links je 3 Meßpunkte occipital rechts und links Auf die cervicalen Meßpunkte wurde verzichtet da die Diagnostik in diesem Bereich erhebliche Fehlerquellen aufweist Weitere 4 Meßpunkte liegen in der Mittellinie

Um eine Speicherung von radioaktivem Jod in der Schilddrüse zu verhindern, wird 24 Stunden vor der Untersuchung die Schilddrüse durch eine intra



Abb 1 Meßplatz fur die Gamma Encephalographie

venose Jod Injektion blockiert Dann werden durchschnittlich 350 μC RISA intravenos injiziert Die erste Messung uber den angegebenen Punkten erfolgt nach 2 Stunden eine weitere 24 Stunden spater

Die so erhaltenen Impuls Werte jedes Meßpunktes werden nun zu einer Kurve verbunden (Abb 3, obere Kurve) Die gestrichelte Linie stellt die Impuls Kurve der rechten Hemisphare dar, die ausgezogene Linie zeigt die Meßwerte der linken Hemisphare Es handelt sich hier um das Untersuchungsergebnis eines hirnorganisch gesunden Patienten wie die weitgehende Deckung

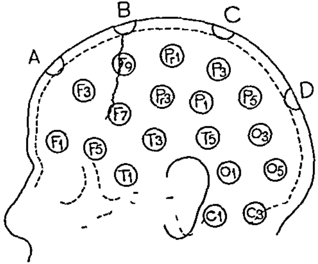


Abb 2 Meßpunkte nach PLANIOL.

der rechten und linken Impuls Kurven erkennen laßt

Um geringe Unterschiede der Impuls Kurven von der rechten und der linken Hemisphäre erfassen zu konnen, wird von beiden Kurven eine Differenz Prozent Kurve gebildet (Abb 3, untere Kurve) Bei Patienten ohne hirnorganische Veranderungen kann die Differenz Prozent Kurve eine Abweichung bis zu 15 % von der Null Linie ergeben Prozent Zahlen bis zu 25 % von der Null Linie entfernt, sind als Herd verdachtig anzusehen *Werte, die daruber* hinausgehen weisen eindeutig auf eine cerebrale Lasion hin

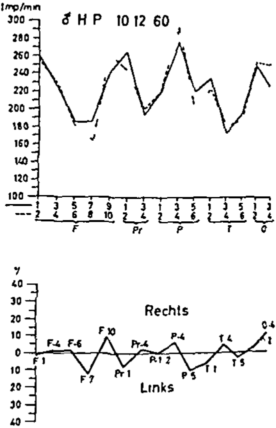


Abb 3 Impulskurven und Differenz Prozent Kurve eines hirnorganisch gesunden Patient

Durch diese Kurven ist sowohl eine Orts Diagnose als auch eine Art Diagnose der cerebralen Lasion moglich In der Abb 4 findet sich z B eine erhebliche *Impuls Erhohung links parietal* die an Intensitat und an Großenausdehnung bei der Messung nach 24 Std nur gering zugenommen hat Dieses Kurvenbild ist typisch fur ein Meningeom

Es handelte sich um eine 35 jahrige Kranke, die wegen einer beginnender Stauungspapille in die neurochirurgisch neurologische Klinik der Freien Universitat Berlin eingewiesen wurde Neurologisch waren keine pathologischen Besonderheiten erkennbar Elektroencephalogramm fraglicher Herd links praecentral Das *Luftencephalogramm zeigte keine* Verdrangungserscheinungen allerdings hatte sich der linke Seitenventrikel nicht mit Luft gefullt Bei der linksseitigen Carotis Arteriographie ließen sich am Endabschnitt der A pericallosa pathologische Gefaße nachweisen (Abb 5 und 6) Die Operation (Prof STENDER) ergab ein huhnereigroßes, von der Falx ausgehendes Meningeom links parietal

Die Abb 7 zeigt bei der Messung nach 2 Std eine diffuse Impuls Erhohung uber der gesamten rechten Hemisphare Bei der Messung nach 24 Std hat die *Impuls Erhohung* erheblich zugenommen, ein Maximum ist von F_{11}—P_4 zu erkennen Diese Zunahme der Impuls Erhohung und auch die Großenausdehnung weisen eindeutig auf ein Glioblastom rechts parietal hin Die Diagnose

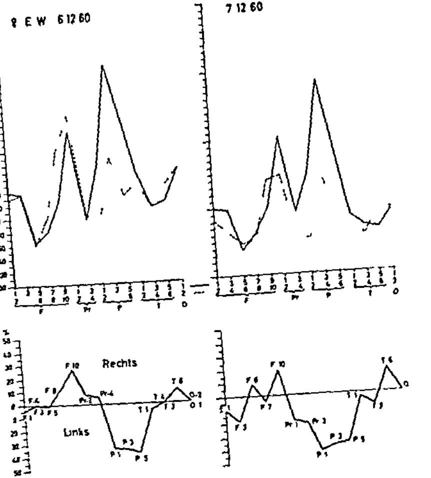


Abb 4 Meß-Ergebnis bei einem Meningeom

[illegible] durch die Carotis Arteriographie (Abb 8) und auch operativ ge sichert

Der Wert der Isotopen Untersuchung wird durch den nachsten Fall be sonders betont.

Bei einer [illegible]jahrigen Kranken traten seit 6 Jahren Jackson Anfalle der linken Extremitaten auf Wiederholte klinische Untersuchungen ergaben keinen [illegible] Anhalt fur einen Hirntumor Bei der Aufnahme in die [illegible]ologische Universitats Klinik fand sich eine maßige [illegible] Parese. Im Elektroencephalogramm waren Herdveranderungen [illegible] rechts erkennbar Durch das Carotis-Arteriogramm l[illegible] [illegible] pathologischer Befund erheben (Abb 9) Bei der Luft [illegible] zeigte sich ein maßiger mittelständiger Hydrocephalus intern

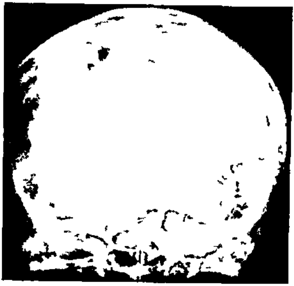



Abb. 5 und 6. Carotis-Arteriogramme von der Patienten in Abb. 4

Ergebnis der Gamma-Encephalographie (Abb. 10). Bei der Messung 2 Std. nach der RISA-Injektion war eine mäßige Impuls-Erhöhung rechts praecentral—parietal erkennbar, die jedoch nicht sicher für einen Tumor sprach. Die Messung nach 24 Std. zeigte dann aber eine maximale Impuls-Erhöhung

Tabelle

Untersuchungsergebnisse der Gamma-Encephalographie

Anzahl der Fälle	Diagnose	Lokalisation von hirnorganischen Veränderungen: genau lokalisiert	nicht lokalisiert
13	Glioblastom	12	1
18	Astrocytom	18	—
5	Oligodendrogliom	5	—
1	Spongioblastom	1	—
6	Ca.-Metastasen	6	—
1	Sarkom	1	—
4	Meningeom	4	—
2	Hämangiom	2	—
3	Hypophysen-Tumor	2	1
1	Pinealom	—	1
1	Eosin. Granulom	1	—
17	Epilepsie (mit EEG-Herd)	10	7
16	ohne path. Befund	—	16
54	Hirntumoren insgesamt	51	3
	Genauigkeit = 94 %		

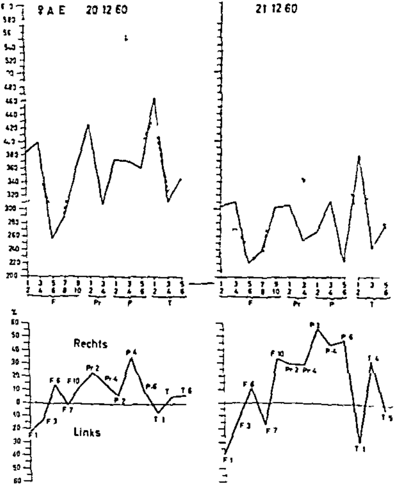


Abb 7 Meß-Ergebnis bei einem Glioblastom



Abb 8 Carotis Arteriogramm on der Patientin in Abb 7



Abb. 9 Carotis-Arteriogramm von der Patientin in Abb. 10

rechts praecentral neben der Mittellinie und eine deutliche Impuls-Erhöhung rechts parietal neben der Mittellinie. Auf Grund dieses Untersuchungsbefundes wurde von uns ein Astrocytom rechts praecentral bis parietal neben der Mittellinie diagnostiziert.

Bei der Probetrepanation fand sich eine makroskopisch unauffällige Hirnrinde. Es bestand auch kein Hirndruck. Bei Punktionen mit der Cushing-Nadel ließ sich kein Tumor-Widerstand feststellen. Die histologische Untersuchung des entnommenen Hirngewebes ergab dann eindeutig ein Astrocytom, so daß die mit der Gamma-Encephalographie gestellte Diagnose bestätigt werden konnte.

Die Tabelle zeigt die Meßergebnisse der einzelnen Untersuchungen. Dabei ist zu betonen, daß die Befunde bei Hirntumor-Patienten arteriographisch, encephalographisch und operativ bzw. histologisch bestätigt werden konnten. Es handelte sich bei den aufgeführten 88 Untersuchungen um 54 Großhirn-Tumoren, von denen 51 exakt lokalisiert wurden. Die Genauigkeit der Tumor-Diagnostik betrug also 94 %. Diagnostische Schwierigkeiten traten lediglich bei Tumoren der Mittellinie auf (Hypophysen-Tumor, Pinealom).

Mit der Gamma-Encephalographie sind wir also in der Lage, die Orts-Diagnose von Hirntumoren mit großer Genauigkeit anzugeben. Es ist aber auch eine Art-Diagnose möglich. Die gutartigen Hirntumoren können von den bösartigen primären Hirngeschwulsten und von Carcinom-Metastasen unterschieden werden. Es zeigte sich, daß die Gamma-Encephalographie in einem Teil der Krankheitsfälle die diagnostische Genauigkeit der Carotis-Arteriographie und der Luftencephalographie übertrifft. Bei der elektroencephalographischen Untersuchung ist zwar bei einem Hirntumor mit großer Sicherheit ein Herdschaden nachweisbar, eine Art-Diagnose des Tumors ist jedoch nur in seltenen Fällen möglich.

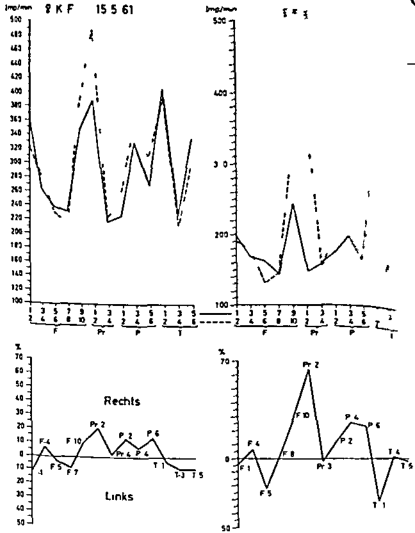


Abb 10 Meß-Ergebn s bei einem Astrocytom

Der Untersuchungs Vorgang ist fur den Patienten nicht belastend Zwischen falle wie sie bei Kranken mit Hirntumoren sowohl bei der Carotis Arteriographie als auch bei der Luftencephalographie moglich sind treten hierbei nicht auf Die Gamma Encephalographie eignet sich besonders zur ambu lanten Untersuchung von diagnostisch ungeklarten Kranken und zum fruh zeitigen Nachweis von Hirntumor Rezidiven Die Gamma Encephalographie soll die bisherigen Untersuchungs Methoden nicht verdrangen ihre Durch fuhrung bedeutet aber eine zusatzliche diagnostische Moglichkeit auf die nicht verzichtet werden sollte

ZUSAMMENFASSUNG

Die extrakranielle Diagnostik von Hirntumoren mit radioaktivem jodiertem Serum Albumin (Gamma Encephalographie) bedeutet einen erheblichen Fortschritt bei der Untersuchung von neurologisch neurochirurgischen Kranken Es ist damit moglich die Orts Diagnose und auch die Art Diagnose von Hirntumoren mit großer Genauigkeit anzugeben Unsere Erfahrungen stutzen sich auf 88 Untersuchungen In 54 Fallen handelte es sich dabei um Hirntumoren von denen 51 exakt lokalisiert wurden Die diagnostische Genauigkeit betrug also 91% Da die Gamma Encephalographie fur den Patienten nicht belastend ist eignet sie sich besonders zur ambulanten Untersuchung von diagnostisch ungeklärten Erkrankungen und zum fruhzeitigen Nachweis von Hirntumor Rezidiven

SUMMARY

The extracranial investigation of brain tumours with radioactive serum albumin (gamma encephalography) represents a significant advance in the diagnosis of neurosurgical conditions. This method permits exact localization and also establishes the character of the lesion The author has undertaken a total of 88 examinations 54 of which proved to be brain tumours out of which 51 could be localized Since gamma encephalography does not affect the patient, he has not to be admitted yet the method clarifies uncertain conditions and helps to diagnose early recurrencies of tumours

RÉSUMÉ

L examen extracranien des tumeurs cérébrales par la sérum albumine radioactive (gamma encephalographie) représente un progrès important dans le diagnostic des affections neurochirurgicales Cette méthode permet la localisation exacte et établit aussi la nature de la lésion. L auteur a fait un total de 88 examens dont 54 ont montré des tumeurs cérébrales parmi lesquelles 51 ont pu etre localisées Comme la gamma-encéphalographie ne gêne pas le malade l hospitalisation n est pas nécessaire cette méthode élucide des cas difficiles et aide au diagnostic precoce des récidives tumorales

LITERATUR

PLANIOL TH Diagnostic des lesions intra-craniennes par les radio-isotopes. Masson Paris 1959

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ANGIOCARDIOGRAPHIC MEASUREMENTS IN CONGENITAL HEART DISEASE IN INFANCY AND CHILDHOOD

I The size of the ascending and descending aorta

by

HÅKAN ARVIDSSON

The diagnosis of congenital heart disease from conventional roentgenograms has improved significantly during the last decade This is undoubtedly due to the increased use of angiocardiography by which the anatomy of the individual heart chambers and great vessels may be studied in detail Furthermore surgical correction is now possible in almost any congenital heart condition and this gives the radiologist the opportunity to control his diagnosis at operation The conventional film interpretation is however not very accurate especially in infancy and when there is a combination of two or more heart malformations

The size and shape of the heart, pulmonary arteries and the aorta constitute the basis for the interpretation of the conventional roentgenograms The size and shape of the aorta is considered a valuable aid in the differential diagnosis Most of the papers dealing with the aortic size contain no objective measurements of the aorta, and the normal size of the aorta is not given As early as in 1949 however, DOTTER and STEINBERG described angiocardiographic measurements of the normal aorta, they found an increase in size of the aorta with increasing age but they did not attempt to correlate the aortic diameter to body size

From the Edward Mallinckrodt Institute of Radiology Washington University School of Medicine Saint Louis Missouri U S A Submitted for publication 17 April 1962

There are numerous statements in the literature on the size of the aorta in congenital heart disease In congenital aortic stenosis most authors have found the aorta to be enlarged DOWNING described the aorta as generally prominent, TAUSSIG said that the ascending aorta may appear dilated, and CAMPBELL & KAUNTZE stated that the aorta is enlarged in aortic valvular stenosis KJELLBERG et coll in conventional roentgenograms in 20 cases of aortic stenosis found a wide aorta in 14 cases, but cases of subaortic stenosis were also included in their material KLATTE et coll , in a systematic study of the aortic size, reported dilatation in 8 out of 13 cases WOOD stated that the aorta was prominent in aortic stenosis

The interpretation of the aortic size in patent ductus arteriosus is somewhat more controversial KJELLBERG et coll analyzed 115 cases of subjects above the age of 3 and found 49 cases of a dilatated aorta, the rest being normal SALTZMAN reported 47 cases (all adults) in 34 of which a definitely enlarged aorta was evident KEATS & STEINBACH found an enlarged aorta in only 11 out of 100 cases A normal aorta was present in all the 90 cases published by STAUFFER, and SHAPIRO stated that the aorta was normal in patent ductus arteriosus

In pulmonary stenosis SALTZMAN described a narrow aorta in 5 cases out of 13 KJELLBERG et coll stated that the aorta was of normal width or narrow KLATTE et coll reported a small aorta in 53 per cent, a normal aorta in 42 and a large aorta in 5 per cent of cases WOOD described the aorta as small and EEK in MANNHEIMER s study on morbus caeruleus stated that the aorta is often hypoplastic SCHWEDEL was of the opinion that the aorta was hypoplastic in pulmonary stenosis

The aortic size in ventricular septal defect with left to-right shunt is not discussed in the majority of the papers dealing with the subject KJELLBERG et coll found a normal or narrow aorta in their material KLATTE et coll had 9[illegible] cases of ventricular septal defect, 67 per cent of which had a small aorta 30 per cent a normal, and 3 per cent a large aorta

The aorta in atrial septal defect is generally considered to be hypoplastic KJELLBERG et coll for instance, observed a narrow aorta in 75 per cent of their cases SALTZMAN 7 cases with a narrow aorta among 13 adults and HEALEY et coll 3 cases with a narrow aorta among 12 cases The latter pointed out the difficulty in the interpretation of the aorta in conventional films NICHOL & BRANNAN and BEDFORD et coll described the aorta as hypoplastic in atrial septal defect

Finally, in Fallot s tetrad KJELLBERG et coll described dilatation of the aorta in a third of their material and this could not be related to the degree of over riding of the aorta SALTZMAN stated that the aorta was normal in size in Fallot s tetrad while KLATTE et coll studied a material of 79 cases and in 63 per cent the aorta was enlarged

In the following an account will be given of direct measurements of the

Table I

Survey of the material with definitions of abbreviations

Diagnosis	No of cases	Average age (years)	Average BSA (m^2)
Ventricular septal defect low pressure PA < 50 mm Hg (VSDL)	25	4 8	0 78
Ventricular septal defect high pressure PA ≥ 50 mm Hg (VSDH)	10	1 7	0 40
Tetralogy of Fallot (ToF)	20	3 9	0 55
Aortic valvular stenosis (AoS)	12	9 0	1 15
Subvalvular aortic stenosis (Sub AoS)	2	8 0	0 90
Aortic stenosis and insufficiency (AoSI)	1	7 0	0 95
Pulmonary valvular stenosis (PS)	15	7.2	0 91
Atrial septal defect (ASD)	10	6 1	0 90
Patent ductus arteriosus (PDA)	12	2 9	0 54
Ventricular septal defect and patent ductus arteriosus (VSD + PDA)	10	1 8	0 42
Normal cases (N)	11	12 0	1.50
Total	128	mean 5.9	mean 0 82

ascending and descending aorta in congenital heart disease Only common heart malformations will be discussed mainly because it was impossible to obtain a significant number of cases of rare malformations

Material and methods

The material consisted of 128 cases, most of which were admitted to St Louis Children s Hospital for the evaluation of congenital heart disease All subjects except one were less than 18 years old The whole case material was thus within the period of life when cardiovascular ageing had not yet started this is of great importance for the study since it was demonstrated earlier that increasing age influences the size of the aorta (DOTTER & STEINBERG, Moss et coll) The males and females were not separated in the present study partly because the groups would have become too small Furthermore there is probably no significant difference in aortic size between the sexes, at least not in the younger age groups BROTMACHER & DEUCHAR found no sex difference in the cardiac index, a fact that gives support to the belief that the aortic size is the same in young males and females

A survey of the material is given in Table 1 in which the different diagnostic groups and number of cases are given the average age and body surface area in m^2 are also presented

The ventricular septal defects were separated into two groups one with a pulmonary systolic pressure lower than 50 mm Hg (VSDL) and one with

higher pressure (VSDH) In the group with a pressure higher than 50 mm Hg it was considered possible that a right to left shunt could be present at exercise but none of the cases were cyanotic at rest

In the group tetralogy of Fallot (ToF) cases of typical appearances on angiocardiography were included, the peripheral oxygen saturation was not taken into consideration (cf KJELLBERG et coll)

In the aortic valvular disease group (AoS) 2 cases of subaortic stenosis and one case of aortic stenosis and insufficiency were included (see fig 4), but these cases will not appear in the statistical analysis The age of the subjects in the aortic disease group was above the average in the other pathologic groups

The pulmonary stenosis (PS) group was relatively homogenous, all cases had valvular stenosis without any signs of infundibular constriction The cardiac index among the cases of pulmonary stenosis did not differ from the one in the normal group (the results on cardiac output will be presented in a later paper in this series)

The size and type of defect in the atrial septal defect (ASD) group were not taken into consideration, both primum and secundum defects were included

Isolated patent ductus arteriosus (PDA) cases were put into one group irrespective of size, but all had a definite left-to-right shunt

Ventricular septal defect in combination with patent ductus arteriosus (VSD + PDA) was observed in a significant number of cases and they formed a separate group although this was too small to warrant a separation on the basis of the pulmonary artery pressure

The so-called normal cases (N) consisted of cases of possible pulmonary vascular disease and cases submitted for cardiac check up because of a murmur All these cases had normal pressures and no shunts, and the angiocardiography was entirely normal both on the dextro- and levocardiogram

The majority of the cases were examined by right sided heart catheterization under general anaesthesia (oxygen, nitrous oxide and fluothane ©) However, subjects above the age of 7 years were usually not anaesthetized The oxygen saturations were measured with a Waters Conley cuvette oximeter and the intracardiac pressures recorded with an 'Electronics for Medicine 5 channel recorder Angiocardiography was performed in connection with the right sided catheterization The contrast medium used was Hypaque® 75 % in a dose of 1 0 to 1 8 ml per kg bodyweight The injection was performed either into the pulmonary artery, right ventricle or the left atrium depending on the catheterization findings A Gidlund pressure syringe was used for the injection and the film changer was of the *Schonander (24 × 36 cm)* biplane type allowing 6 exposures per second The roentgen tubes were operated with two Dynapulse units with a maximum exposure time of 5 millisec the exposure time varied between 2 and 5 millisec and the voltage between 85 and 105 kV The injection was performed either into the left ventricle or the aorta after retrograde aortic catheterization in cases with left sided lesions Both right



Fig 1 Schematic drawing of lateral angiocardiogram The points of measurements for the ascending and descending aorta are marked by horizontal lines All measurements were performed on films exposed in systole

and left sided injections were performed in a few cases Simultaneous recordings of ECG, injection and exposures were taken during angiocardiography in order to secure the cardiac phase of each exposure and the heart rate during angiocardiography

Method of measurement (see Fig 1) The diameter of the ascending aorta was measured at its widest point in the lateral projection Films exposed during mid systole or late systole were chosen for the measurements This was done in order to avoid errors due to systo diastolic diameter changes in the ascending aorta, changes that were occasionally considerable The measurements were performed with an accuracy of $\pm$ 1 mm

The geometrical distortion due to the divergence of the roentgen rays was determined individually in each case according to well known principles and the aortic diameter was corrected by the calculated magnification factor The area was determined from the corrected aortic diameter under the assumption that the aorta had a circular cross section The diameter and cross sectional area of the descending aorta were determined according to the same principles but it was occasionally easier to measure the descending aorta in the a p projection The point of measurement was well below the isthmus region where the diameter is difficult to determine due to tapering of the aorta The infundibulum in patent ductus arteriosus also makes the diameter determination difficult in this region An infundibular deformity is occasionally present in cases without a patent ductus (JONSSON & SALTZMAN)

It is extremely important for the accuracy of the measurements to avoid a Valsalva effect during angiocardiography increased intrabronchial pressure reduces the size of the aorta considerably In order to avoid this effect the subjects under general anaesthesia were not inflated excessively during angiocardiography and those examined without general anaesthesia were instructed to take a deep breath but not to strain The effect of an increased intrathoracic pressure is delayed and the earliest films with the aorta contrast filled were therefore chosen for measurements

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The majority of the cases were examined by right sided heart catheterization under general anaesthesia (oxygen, nitrous oxide and fluothane ©) However, subjects above the age of 7 years were usually not anaesthetized The oxygen saturations were measured with a Waters Conley cuvette oximeter and the intracardiac pressures recorded with an 'Electronics for Medicine 5-channel recorder Angiocardiography was performed in connection with the right sided catheterization The contrast medium used was Hypaque® 75 % in a dose of 1 0 to 1 8 ml per kg bodyweight The injection was performed either into the pulmonary artery, right ventricle or the left atrium depending on the catheterization findings A Gidlund pressure syringe was used for the injection and the film changer was of the Schonander (24 × 36 cm) biplane type allowing 6 exposures per second The roentgen tubes were operated with two Dynapulse units with a maximum exposure time of 5 millisec the exposure time varied between 2 and 5 millisec and the voltage between 85 and 105 kV The injection was performed either into the left ventricle or the aorta after retrograde aortic catheterization in cases with left sided lesions Both right



Fig 1 Schematic drawing of lateral angiocardiogram The points of measurements for the ascending and descending aorta are marked by horizontal lines All measurements were performed on films exposed in systole

and left sided injection ... in a few cases Simulta... of ECG, injection and ... taken during angioca... order to secure the card... each exposure and the heart ... angiocardiography

Method of measurement (... The diameter of the ascend... was measured at its wides... the lateral projection Films ... during mid systole or late sys... chosen for the measurements T... done in order to avoid errors ... systo diastolic diameter changes ... ascending aorta changes that ... occasionally considerable The ... urements were performed with an ... racy of ± 1 mm

The geometrical distortion due to the divergence of the roentgen rays was determined individually in each case according to well-known principles and the aortic diameter was corrected by the calculated magnification factor The area was determined from the corrected aortic diameter under the assumption that the aorta had a circular cross section The diameter and cross sectional area of the descending aorta were determined according to the same principles but it was occasionally easier to measure the descending aorta in the a p projection The point of measurement was well below the isthmus region where the diameter is difficult to determine due to tapering of the aorta The infundibulum in patent ductus arteriosus also makes the diameter determination difficult in this region An infundibular deformity is occasionally present in cases without a patent ductus (JÖNSSON & SALTZMAN)

It is extremely important for the accuracy of the measurements to avoid a Valsalva effect during angiocardiography, increased intrabronchial pressure reduces the size of the aorta considerably In order to avoid this effect the subjects under general anaesthesia were not inflated excessively during angiocardiography and those examined without general anaesthesia were instructed to take a deep breath but not to strain The effect of an increased intratho pressure is delayed and the earliest films with the aorta contrast filled therefore chosen for measurements

Table 2

Regression equations and correlation coefficients in the relation between body surface area and cross sectional area of the descending aorta

Group	Regression equation	Observations	R^2
VSDL	$Y = 2.31 + 3.34 (X - 0.78)$	25 observations	$R^2 = 0.71$
VSDH	$Y = 1.30 + 2.76 (X - 0.40)$	10 observations	$R^2 = 0.37$
ToF	$Y = 2.37 + 3.74 (X - 0.55)$	20 observations	$R^2 = 0.65$
AoS	$Y = 6.92 + 6.13 (X - 1.15)$	12 observations	$R^2 = 0.53$
PS	$Y = 2.68 + 3.20 (X - 0.91)$	15 observations	$R^2 = 0.85$
ASD	$Y = 2.46 + 3.59 (X - 0.90)$	10 observations	$R^2 = 0.68$
PDA	$Y = 1.90 + 3.43 (X - 0.51)$	12 observations	$R^2 = 0.56$
VSD + PDA	$Y = 1.48 + 4.52 (X - 0.42)$	10 observations	$R^2 = 0.88$
N	$Y = 4.11 + 4.01 (X - 1.50)$	11 observations	$R^2 = 0.89$

Y cross-sectional area of the ascending aorta
X body surface area (m^2)
R^2 *square of the linear correlation coefficient*

Correction of aortic size for differences in bodily development. In a patient material of varying bodily development it is necessary to find a method of correcting the aortic size by some factor that expresses the size of the subject. Moss et coll. correlated the diameter of the descending aorta to the age and found a relatively good correlation in the younger age groups. It has been shown by several Swedish authors that there was a good correlation between total heart volume and body surface area (LILJESTRAND et coll., LIND, MALREA et coll.). This latter method was tried for the aorta. Both the diameter and the cross sectional area of the aorta were correlated to the body surface area. The cross sectional area proved to be slightly superior to the diameter for the correlation and this was consequently used.

Results

1. *Ascending aorta.* The cross sectional area of the ascending aorta was correlated to the body surface area in the different diagnostic groups. The values obtained were analyzed statistically. The number of observations, the regression equations and the squares of the correlation coefficients are given in Table 2. The coefficients of correlation are reasonably good within all groups except for the high pressure ventricular septal defects (VSDH).

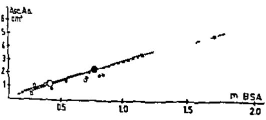


Fig 2 Graphic demonstration of the correlation between body surface area (BSA) and cross sectional area of the ascending aorta (Asc Ao) The solid lines are the regression equations for ventricular septal defects with high (for VSDH) and low pressure (for VSDL) The common regression line for the whole material except for cases of aortic stenosis and Fallot's tetrad is dotted The regressions for the two groups fall very close to the common regression line

Graphic representations of the observations within the different diagnostic groups are given in Figs 2 to 7 The single observations are represented by small dots and the large circles are the means within the groups, the dotted line in each figure is the regression line for the whole material except the aortic stenoses and the cases of Fallot's tetrad The slopes of the regression lines are within the same order of magnitude in all groups except for the aortic stenoses where the slope is considerably steeper Apart from the cases of aortic stenosis there is only one group that appears to differ from the rest of the material namely the cases of Fallot's tetrad which seem to have a larger aorta in relation to body surface area A co variance analysis of the whole material showed that there was a significant difference between the groups A further co-variance analysis with the aortic stenosis and Fallot's tetrad cases excluded showed that there was still a slight difference within the residual groups but considerably less than before the exclusion of the two groups The residual material was thus considered as homogenous and the regression equation for this material was found to be $Y = 2.35 + 2.90\ (X - 0.79)$ or approximately $Y \approx 3X$ $R^2 = 0.68$ (dotted line in Figs 2 to 7)

Y is the cross sectional area of the ascending aorta in cm² and X the body surface area in m² The standard error at the average body surface area is 0 83, which implies that the individual variations in aortic size are considerable

2 *Descending aorta* The observations of the descending aorta were analyzed by the same method as those for the ascending aorta and the regression equation, number of observations, and squares of correlation coefficients are

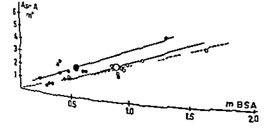


Fig 3 Graphic demonstration similar to fig 2 for tetralogy of Fallot (for ToF) and pulmonary valvular stenosis (for PS) The regression line for ToF is slightly elevated from the common regression line but for PS the regression is practically the same as for the common material

Table 3

Regression equations and correlation coefficients in the relation between body surface area and cross sectional area of the descending aorta

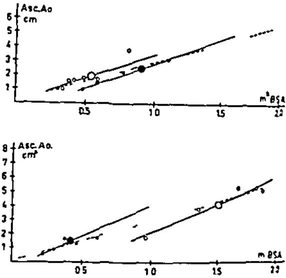
Group	Equation
VSDL	$Y = 0.90 + 1.40\,(X - 0.78)$
	25 observations $R^2 = 0.65$
VSDH	$Y = 0.41 + 1.08\,(X - 0.40)$
	10 observations $R^2 = 0.71$
ToF	$Y = 0.72 + 1.46\,(X - 0.55)$
	20 observations $R^2 = 0.79$
AoS	$Y = 1.52 + 1.75\,(X - 1.15)$
	12 observations $R^2 = 0.82$
PS	$Y = 1.10 + 1.45\,(X - 0.91)$
	15 observations $R^2 = 0.85$
ASD	$Y = 1.03 + 1.20\,(X - 0.90)$
	10 observations $R^2 = 0.64$
PDA	$Y = 0.72 + 1.55\,(X - 0.54)$
	12 observations $R^2 = 0.84$
VSD + PDA	$Y = 0.58 + 1.99\,(X - 0.42)$
	10 observations $R^2 = 0.90$
N	$Y = 2.14 + 1.76\,(X - 1.50)$
	11 observations $R^2 = 0.74$

Y cross sectional area of the descending aorta
X body surface area (m²)
R^2 square of the linear correlation coefficient

given in Table 3. The correlation between aortic cross sectional area and body surface area was better for the descending than for the ascending aorta. A covariance analysis on the figures from the descending aorta showed that there was no difference between the groups. All the observations are consequently given in the same diagram (Fig. 8). The regression equation for the whole material was found to be $Y = 0.99 + 1.46\,(X - 0.78)$ or roughly $Y \approx 1.5\,X$, $R^2 = 0.84$, where Y is the cross sectional area of the descending aorta and X the body surface area in m². The standard error was 0.27, i.e. the deviation was less than for the ascending aorta.

Discussion

The size of the aorta is considered to play an important part in the differential diagnosis of congenital heart disease from conventional roentgenograms. Several factors make the interpretation difficult. Only the right border of the ascending aorta is visible, the left border being hidden within the mediastinum, the size of the descending aorta is also difficult to evaluate as only the left contour is seen in the films. When the oesophagus is barium filled the aortic arch is often accessible for measurement, even though the accuracy is not very high because of the varying relationships between the aortic arch and



Figs 5—6 Graphic demonstrations similar to fig 2 In fig 5 (above) patent ductus arteriosus (for PDA) and atrial septal defect (for ASD) are plotted The regression lines fall close to the common regression line (broken line) In fig 6 (below) ventricular septal defect + patent ductus arteriosus (for VSD + PDA) and the normal (for normal) cases are demonstrated The two materials show slightly steeper regression lines than the common material in VSD + PDA this is mainly due to one single observation The difference between the normals and the common material is not statistically significant

that the correlation to body surface was slightly better than to age They included cases with left to-right and right to left shunts in their material, and the size of the descending aorta did not differ from the normal cases without a shunt The observations made in the present material are in full agreement with the findings published by Moss et coll in 1959

In order to investigate if there was a correlation between age and aortic size in the present material, age and body surface area were correlated The graphic demonstration in Fig 8 shows the very good linear correlation between age in years and body surface area only the means in the different diagnostic groups are plotted It should be noted that there is no definite underdevelopment in any of the diagnostic groups, as could be expected at least among the cases of 'tetralogy of Fallot' and ventricular septal defects with high pressure The linear correlation between age and body surface area may be expressed by the following regression equation

$BSA = 0\ 19 + 0\ 11$ age in years $R = 0\ 98$

Since there is a linear correlation between aortic size and body surface and between body surface and age there must also exist a linear correlation between age and aortic size This relationship was not studied in detail but for the ascending aorta in all cases except aortic stenosis and Fallot s tetrad the regression equation is

Asc aorta in $cm^2 = 0\ 68 + 0\ 30$ age

and for the descending aorta in all cases

Desc aorta in $cm^2 = 0\ 16 + 0\ 15$ age

These formulas are not valid in the higher age groups and should probably not be used in subjects above the age of 15 years

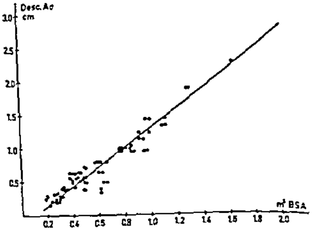


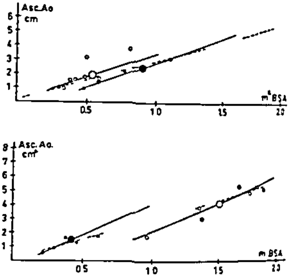
Fig 7 Descending aorta in cm plotted against body surface area in m All diagnostic groups are plotted together since no statistical difference between the groups was found in the co-variance analysis

Several observations made in the present study are in disagreement with generally accepted ideas on aortic size in congenital heart disease

1 The ascending aorta is small neither in atrial nor in ventricular septal defects
2 The ascending aorta is not enlarged in patent ductus arteriosus
3 The ascending aorta is normal in size in pulmonary valvular stenosis
4 The size of the descending aorta is the same in all common types of congenital heart disease

The observations were made in infants and children and might not be valid for an adult case material

The writer was of the opinion before the present analysis was completed that the aorta was wide in patent ductus arteriosus and narrow in atrial septal defect and sought some explanation of this common misinterpretation of conventional roentgenograms When no direct measurements are made of the aorta and the size is estimated only in a subjective manner it must be compared to the size of some other thoracic structure Comparison may be made to the transverse diameter of the thorax or as seems more easy and logical to the size of the heart This latter method of comparison is probably the reason for the misinterpretation of aortic size In atrial septal defect the heart especially its right side is usually considerably enlarged the enlargement of the right atrium obscures the view of the ascending aorta and furthermore the size of the heart makes the aorta appear hypoplastic In patent ductus arteriosus the cardiac enlargement is usually more moderate than in atrial septal defect and the enlargement is more or less restricted to the left side of the heart The projects more "freely from the heart and is more easily distingu



Figs 5—6 Graphic demonstrations similar to fig 2 In fig 5 (above) patent ductus arteriosus (for PDA) and atrial septal defect (for ASD) are plotted The regression lines fall close to the common regression line (broken line) In fig 6 (below) ventricular septal defect + patent ductus arteriosus (for VSD + PDA) and the normal (for normal) cases are demonstrated The two materials show slightly steeper regression lines than the common material in VSD + PDA this is mainly due to one single observation. The difference between the normals and the common material is not statistically significant

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Asc aorta in cm² = 0 68 + 0 30 age

and for the descending aorta in all cases

Desc aorta in cm² = 0 16 + 0 15 age

These formulas are not valid in the higher age groups and should probably not be used in subjects above the age of 15 years

study shows that only the ascending aorta is widened and to a very moderate degree, the most probable explanation of this enlargement of the ascending aorta is consequently the abnormal septation of the primitive truncus arteriosus

The increase in size of the ascending aorta in aortic valvular stenosis is obvious from the present study as well as from many earlier observations The explanation of poststenotic dilatation is purely haemodynamic (HOLMAN) and the degree of dilatation is independent of the degree of stenosis

Poststenotic dilatation is restricted mainly to the part of vessel peripheral to the stenosis where it is a single tube After a bifurcation, such as at the origin of the innominate artery, poststenotic dilatation is no longer present This is substantiated by the observation that no dilatation of the descending aorta was found in the present material of aortic valvular disease There is usually no dilatation of the ascending aorta in subaortic stenosis KLATTE et coll reported two cases of subaortic stenosis, one of which had poststenotic dilatation The two cases presented in this paper support the idea that there is no poststenotic dilatation in subaortic stenosis (see Fig 4)

SUMMARY

The sizes of the ascending and descending aorta in 128 cases of congenital heart disease as well as in normal controls of infants and children were measured at angiography The generally accepted ideas on aortic size in congenital heart disease are discussed and a possible explanation given of the misinterpretation of aortic size in conventional films

ZUSAMMENFASSUNG

Die Weite der Aorta ascendens sowie die Weite der Aorta descendens wurde in 128 Fallen von angeborenen Herzfehlern bei Kindern und Kleinkindern auf angiographischen Filmen gemessen und mit Normalfällen verglichen Die vorherrschenden Ideen uber die Aortenweite bei angeborenen Herzfehlern werden diskutiert und Fehler bei der Schatzung der Aortenweite in gewohnlichen Rontgenbildern werden erklart

RÉSUMÉ

L auteur a mesuré angiographiquement les dimensions de l aorte ascendante et descendante dans 128 cas d affection cardiaque congénitale ainsi que chez des nourrissons et des enfants normaux Il examine les idées généralement acceptées concernant les dimensions de l aorte dans les maladies cardiaques congénitales et donne une explication possible de la mau aise interprétation des dimensions de l aorte mesurées sur les radiographies simples

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LATE EFFECTS OF THOROTRAST IN CEREBRAL ANGIOGRAPHY

by

R BLOMBERG, L E LARSSON, B LINDELL and E LINDGREN

The contrast medium Thorotrast (a colloidal solution of thorium dioxide) and its possible deleterious effects have been widely discussed, especially from the viewpoint of its radioactivity Survey studies have recently been published by LOONEY (1960), and BASERGA et coll (1960) After intravascular injection the thorium dioxide is almost completely retained in the reticulo-endothelial system and remains there for life The radiation doses particularly in the liver and the spleen, are quite high but difficult to assess because of the granular deposits and the short range of the α particles The order of magnitude seems to be some hundred rads per year as the average α dose in the liver and the spleen in any event the dose is sufficiently high to risk producing radiation injuries The number of cases reported in the literature is however rather small and limited to a few specific effects LOONEY referred to 29 cases of malignant tumours reported to have occurred after Thorotrast injection while BASERGA et coll listed 36 cases In a literature survey DAHLGREN (1961) found 61 cases of Thorotrast induced malignancies

The scarcity of known malignant tumours following Thorotrast injection is probably due to the small size of the groups hitherto studied LOONEY listed 7 follow up studies comprising a total of 5 123 cases but these included the investigation by THOMAS HENRY & KAPLAN (1951) in which questionnaires were sent to 132 radiologists claiming 4 235 patients The true number is therefore possibly much less than 5 000 cases

Presented in abstract at the 6th Symp Neuroradiologicum Rome 1961 Submitted for publication 16 January 1962

Table I

Available material

Year of examination	Number of cases (max estimate)[1]	Number of cases for which the records indicate Thorotrast injections	Number of cases known to have been examined with Thorotrast (min estimate)	
			n	p
1932	12	1	4	8
1933	24	2	9	15
1934	28	3	12	16
1935	61	5	41	30
1936	74	4	50	24
1937	73	19	40	33
1938	79	57	35	44
1939	95	50	38	57
1940	97	43	45	52
1941	129	89	59	60
1942	142	72	59	83
1943	84	55	26	29
1944	72	24	9	15
1945	57	14	4	10
1946	76	1	—	1
1947	15	—	—	—
	1 118	439	431	477
			908	

[1] Up to 1942 the figures include all examinations After 1942 cases for which the records indicate other contrast medium than Thorotrast have been excluded

During the years 1932—1945 Thorotrast was used for cerebral angiography at Serafimerlasarettet in approximately one thousand cases Since this would seem to be a substantial number compared to the groups already investigated it was decided to initiate a follow up study on a readily available sample This was felt to be of particular interest since sufficient time had elapsed to permit observation of late effects on the assumption of a latent period of about 20 years for the appearances of radiation induced malignancies as suggested from various other investigations The malignancies attributed to Thorotrast may be classified broadly in two groups tumours at the site of injection and tumours of the liver and the spleen

Material

Up to and during 1942, 814 cases were subjected to cerebral angiography at Serafimerlasarettet During this period Thorotrast was the only contrast medium in use, after 1942, the records of 94 cases show that Thorotrast was

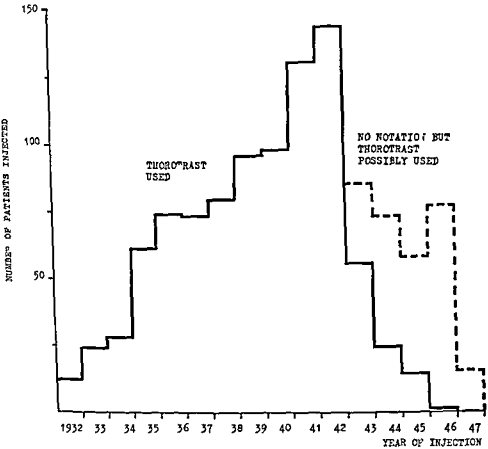


Diagram 1 Annual number of Thorotrast injections The dotted line represents the maximum estimate (Cf Table 1)

injected The total number of cases known to have received Thorotrast is therefore 908 In addition, 210 cases were examined after 1942 without any notation having been made of the type of contrast medium used Some of these cases may have had Thorotrast injections although this is less likely during the years 1946 and 1947 at which time Thorotrast was used only in cases with a short life expectancy The material is presented in Table 1 and Diagram 1

The total of 908 cases, known to have received Thorotrast may be divided into two groups n and p, as shown in Table 1 There were 431 cases with normal roentgen findings (group n) and 477 cases with pathologic changes (group p) mostly tumours The 431 normal cases were taken to comprise the gross sample which was used for the follow up study Of this group we have not been able to follow the hospital records of more than 160 cases here referred to as the proper sample up to 1959

Table 2

Available data on the gross sample of 431 cases of group "n"

Year	Not traced	Known to be living	Known to be dead	Total known
1950	233	115	83	198
1955	245	96	90	186
1959	271	58	102	*160* (proper sample)
1960	297	29	105	134

"n" indicates normal roentgen findings.

Records from the roentgen department: On the forms used for record purposes data were available on the patient's identity, hospital department, roentgen findings and, in some cases, also on the amount and type of contrast medium used. This primary information was available for practically all of the case material.

Records from ward departments: The majority of the cases had been sent for examination from the neurological and neurosurgical departments of Serafimer lasarettet. It was mainly the records of the latter department that enabled us to follow cases up to 1959, which was the condition stipulated for the "proper sample" (see Table 2).

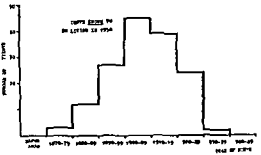
Additional sources of information: A number of cases were traced due to the fact that they had developed some condition which led to the recognition of Thorotrast deposits. In some cases it is difficult to ascertain whether they would also have been found through the record follow up and hence should belong to the "proper sample".

It is known that extravascular injection of Thorotrast may lead to severe complications, and special attention was therefore paid to this aspect. The 19 cases of extravascular injections which were found through the records of the roentgen department were followed up by inquiries to other hospitals and personal contacts, irrespective of whether they belonged to groups "n" or "p". In addition a number of extravascular injections were discovered in the follow up of the group "n" ward records, or as a result of literature studies (Blomquist & Freidenfelt 1959, and Novik 1960) or incidental information. These additional cases are not included in the "proper sample".

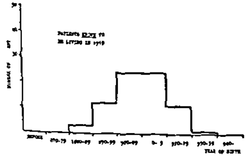
An attempt was made to correlate the total material to that of the Swedish Cancer Registry, which includes all cancer cases in Sweden from 1958. This yielded information on one case of malignancy.



a



b



c

Diagram 2 Birth data for the material
a) Total material
b) Patients known to be living in 1950
c) Patients known to be living in 1959

Statistical data derived from the records

Age distribution The distribution of the total material according to year of birth is shown in Diagram 2 (a) while the corresponding distributions for the patients alive in 1950 and 1959 are given in (b) and (c), respectively, of Diagram 2

Age at the time of injection The age distribution at the time of examination of 1 010 patients, for which age data were available is shown in Diagram 3

Quantities of Thorotrast injected The records gave information on the amount of Thorotrast injected in 436 cases of the total material (see Diagram 4) The most frequent practice involved two injections of about 9 ml each, only 5 cases are recorded as having received more than 40 ml

Case findings

Consequences of extravascular injection Information on the 35 patients in the total material, who are known to have had extravascular injection of Thorotrast is presented in Table 3 In all but one case the location of the extravascular

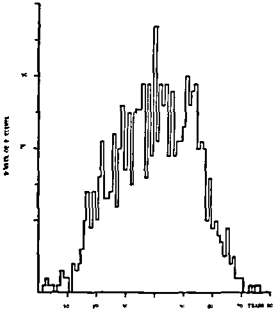


Diagram 3 Age distribution of the patients at the time of injection

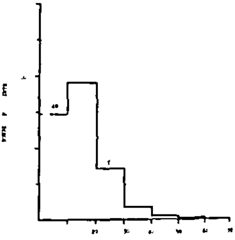


Diagram 4 Amounts (in ml) of Thorotrast injected

deposit was in the vicinity of the carotid bifurcation, in one case the deposit was around the proximal part of the vertebral artery

Of the 35 known cases with extravascular deposits, 8 patients died within the first two years after the injection, in most cases from the cerebral disease that had been investigated, and 4 cases could not be traced of the remaining 23 patients 18 were alive in 1959

The number of cases with pathologic changes that can be ascribed to the extravascular Thorotrast injection in the group of 23 cases totals 12

The typical complication of the extravascular deposit is the local formation of fibrous tissue often combined with nerve injuries (thorotrastoma) and in severe cases necrosis of the pharynx In Table 3, all cases referred to as thorotrastoma (the only consequence in 7 cases) include injuries to adjacent nerves Pharynx necrosis appeared in 3 of the 12 cases Swallowing difficulties associated with the necrosis caused the death of one patient from bronchopneumonia 10 years after the development of the condition Two of the 12 cases developed malignant tumours at the site of injection, in one case the tumour was *clinically and histologically verified as a neuro-fibrosarcoma* Several attempts were made at radical surgical removal of this growth although without success The tumour finally invaded the vertebral canal, with resulting tetraplegia and the patient died following operation In the other case the histologic examination revealed sarcomatous changes of a neurofibroma as well as a mesothelioma of the cervical pleura adjacent to the Thorotrast granuloma

Table 3

Consequences of extravascular injection of Thorotrast

Group	Year of injection	Age at time of injection	Consequences and conditions: Dead without known symptoms	Dead or living with subjective symptoms*	Living without subjective symptoms
n	1935	20		Thorotrastoma 1945 (dead 1947)[1]	
n	1935	42	Leukaemia 1950		
n	1935	17		Thorotrastoma 1951 (living 1960)	
n	1936[2]	25	Unknown		
n	1936	41		Necrosis of pharynx 1948 (dead 1958)[2]	
n	1936	33			1960
n	1937	38		Necrosis of pharynx 1958 (living 1959)	
n	1937	36			1960
n	1938	47	Tum. cer 1938		
n	1938	31		Thorotrastoma 1958 (living 1959)	
n	1938	51	Unknown		
n	1939	49	Haem. cer 1939		
n	1940	38	Stat epil 1942		
n	1940	42			1960
n	1940	22			1960
n	1941	47			1959
n	1941	2			1960
n	1943	40			1960
n	1944	33	Unknown after 1951		
n	1944	42	Insuff cordis 1951		
p	1943	35	Emb pulm 1943		
p	1934	19		Neu ofibrosarcoma + Mesothel oma 1959 (dead 1959)	
p	1935	35		Thorotrastoma 1953 (dead 1961)	
p	1936	19		Thorotrastoma 1956 (living 1959)	
p	1941	16		Thorotrastoma 1959 (living 1959)	
p	1941	22		Neu ofibro arcoma 1960 (dead 1961)	

* First figure denotes year of man festat on

By accident — In b onchopneumon a caused by difficulties n swallowing — Vertebralis-angiography — In circulatory insufficiency after operat on of the neurofibrosa coma — In hepat c cancer — Afte operat on of the neurofibrosarcoma wh ch had penetrated into the vertebral canal

Table 3 *(Cont)*

Group	Year of injection	Age at time of injection	Consequences and conditions		
			Dead without known symptoms	Dead or living with subjective symptoms*	Living without subjective symptoms
p	1936	34	Insuff.cordis 1938		
p	1936	21			1960
p	1937	35	Tum. cer 1938		
p	1943	38	Unknown		
p	1935	30		Thorotrastoma 1959 (living 1960)	
p	1944	47		Necrosis of pharynx 1956 (living 1960)	
p	1945	40	Tum. cer 1945		
p	1945	32	Tum. cer 1946		
p	1946	40			1960
Total	4 unknown		10	12	9 = 35 in all

* First figure denotes year of manifestation

(Novik) The latent periods between the time of injection and time of appearance of the tumour were 19 and 25 years, respectively

The findings do not permit any accurate estimate of the frequency of the above mentioned complications of extravascular Thorotrast injections In the present material of 908 cases, the frequency of extravascular injections was shown to be at least 3 per cent although the injections were made into the vessel by surgical exposure, this, however, is a minimum estimate The frequency of injuries within the group of cases with extravascular deposits might be assessed as 12 23 but this estimate is probably high since 6 of the 12 cases came to our knowledge through incidental information However, as some of the 9 cases apparently unaffected may later develop symptoms, the frequency may nevertheless be estimated at about 50 per cent

Hepatic tumours As shown in Table 4, six cases of malignant primary hepatic tumour were found in the total material, 2 of which fall within the proper sample Although these are low numbers, they indicate an occurrence of the order of 1 per cent Five were cases of hepatic cancer and one of malignant hemangio-endothelioma In the first 2 cases only biopsy diagnoses were available since no post mortem examinations were performed in the other 4 cases these were carried out All of the patients died of malignant disease within one and a half years after the diagnosis had been made

Table 4

Cases of malignant primary hepatic tumours

Group	Year of injection	Age at time of injection	Injected quantity (ml)	Latent period	Year of death
n	1934	35	45	22	1957 (Biopsy diagnosis)
n	1936	26	unknown	19	1957 (Biopsy diagnosis)
p	1935	35	45	26	1961 (Postmortem)
p	1936	31	unknown	22	1958 (Postmortem)
p	1938	43	34	21	1959 (Postmortem)
p	1933	26	unknown	27	1960 (Postmortem)

It should be noted that in the 3 cases for which data are available the amount of Thorotrast injected was 45, 45 and 34 ml, respectively In relation to the distribution shown in Diagram 4, there is a definite suggestion of a correlation between the occurrence of these hepatic tumours and the amount of Thorotrast injected This is further illustrated in Diagram 5

Of the 5 patients known to have received more than 40 ml of Thorotrast 2 died within a year after the examination Of the other 3 patients, 2 are known to have survived more than 20 years after the injection both developed hepatic cancer One of the 5 patients has not been traced

Diagram 5 shows the latent period as a function of the year of Thorotrast injection The distribution of the observations may be explained either by a true latent period exceeding 19 years or by a possible difficulty of obtaining adequate information on hepatic tumours occurring before 1956 The latter explanation is, however, contradicted by the fact that no growths were found in cases injected with Thorotrast later than 1938 In addition the assumption that cases prior to 1956 have escaped discovery would imply that the total number of cases is substantially higher than 6 According to the Swedish Cancer Registry the number of malignant primary intra hepatic tumours in 1958 was 127 for the whole of Sweden, corresponding to a frequency of less than 20 annual cases per million of the total population It is difficult to estimate the expectancy of such hepatic tumours in a population of the present size age distribution, and period of observation and some spontaneous occurrence cannot be excluded

All observations combined, namely the number of observed cases, the apparent latent period and the data on the amount of Thorotrast injected seem to provide a good case for the assumption of a cause effect relationship even if each observation in itself is not entirely convincing On the assumption that the Thorotrast deposit in the liver may give rise to a malignant tumour, there appears to be a latent period of at least 19 years between the Thorotrast injection and the appearance of the tumour

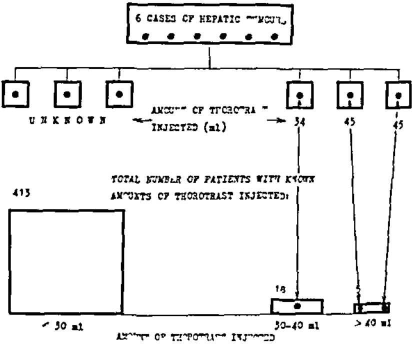


Diagram 5. Correlation between the six hepatic tumours and the amount of Thorotrast injected.

Blood disorders. Only four cases of severe blood disorders were found in the total material: 2 cases of anaemia and 2 cases of leukaemia (Table 5).

The 2 cases of anaemia are attributed to the Thorotrast injections in the hospital records, but the over-all picture of the first case does not support this assumption since it has been possible to keep this case of anaemia under clinical control over the period 1953—1960.

The type of lymphatic leukaemia is not known in the first case; the relatively large amount (25 ml) of Thorotrast administered would seem to suggest

Table 5

Blood disorders

Group	Year of injection	Age at time of injection	Injected quantity (ml)	Latent period (years)	Year of death	Disorder
II	1935	17	Unknown	15	Alive 1960	Anaemia
II	1940	46	16	20	1960	Anaemia
II	1935	41	25	15	1950	Lymphatic leukaemia
II	1939	27	8	17	1957	Myel. leukaemia

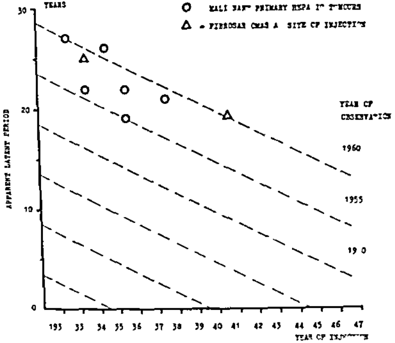


Diagram 6 Apparent latent periods of the malignancies found in the study

a cause effect relationship, but only if the form of leukaemia were acute The second case is less likely to have been radiation induced, since the amount of Thorotrast injected (8 ml) is low

BACKER (1957) has carried out follow up studies over several years on peripheral blood disorders in cases that had received Thorotrast injections He was unable to find a correlation between the amount of thorium used and blood disorders Although the present study was principally devoted to malignancies the narrow examination of the case records did not indicate that Thorotrast deposits would cause an increase in the incidence of peripheral blood disorders This is in agreement with BACKER s study It is sometimes suggested that Thorotrast deposits may reduce resistance to infections This study has produced no evidence to support this surmise

Conclusion

It is apparent that extravascular injections of Thorotrast involve a high risk of severe even fatal consequences The malignant tumours observed that may be related to the Thorotrast have shown a range of latent periods between 19 and 27 years 29 years being the longest period available in

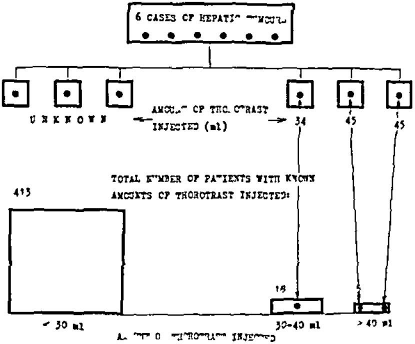


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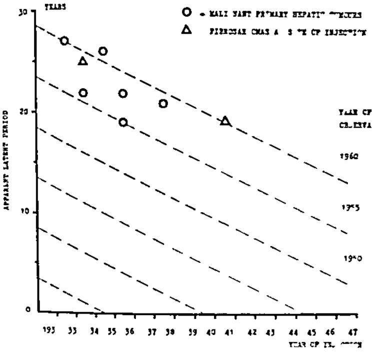


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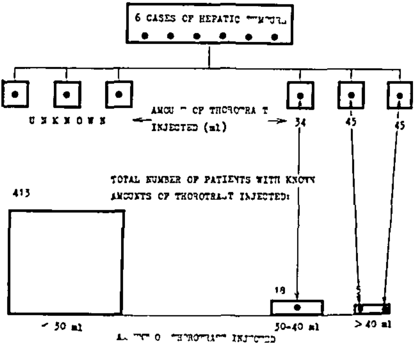


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n	1939	27	8	17	1957	Myeloid leukaemia

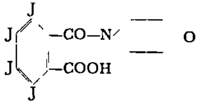
FROM THE ROENTGENDIAGNOSTIC DEPARTMENT (DIRECTOR PROF K LINDBLOM), THE MEDICAL DEPARTMENT (DIRECTOR PROF H LAGERLOF), KAROLINSKA SJUKHUSET, AND THE KING GUSTAF V RESEARCH INSTITUTE (DIRECTOR PROF G BIRKE), STOCKHOLM SWEDEN

ORNITHINE CARBAMOYL TRANSFERASE ACTIVITY IN THE SERUM AFTER SUPPLY OF TETRA-IODOPHTHALIC ACID MORPHOLIDE

by

JAAN NOVEK and HANS REICHARD

The methyl glucamine salt of 3, 4 5, 6 tetra iodophthalic acid morpholide (Ph 761/3, Pharmacia AB) is a biliary contrast medium of the structural formula shown below



The LD_{50} of this substance for the mouse is 1 7 g/kg bodyweight when administered intravenously (SKAGIUS) It was found in an earlier study in the rabbit (NOVEK 1961) that Ph 761/3 was excreted in the bile in concentrations that rose sharply with the quantity administered With large doses the concentration of iodine in the choledochus bile was twice that obtained with another biliary contrast medium Biligrafin forte© (Schering AG) It was also observed that on injecting Ph 761/3 in doses of from 0 06 g to 0 32 g/kg body weight the quantity of bile was reduced by about 50 per cent

Submitted for publication 17 May 1962

this study One case of severe anaemia but no definite case of leukaemia attributable to Thorotrast were found The hepatic tumours were found in cases examined during the period 1933—1938 and the fibrosarcomas in cases examined 1934 and 1941, respectively Since about a half of the total material was examined later than 1938 and the shortest latent period hitherto observed is 19 years, the follow up study will continue

SUMMARY

A follow up study of part of a total material of about 1 000 cases which received Thorotrast injections during the years 1932—1947 is reported Special attention was paid to the appearance of malignancies and the consequences of extravascular deposits of Thorotrast About half the cases that received extravascular deposits developed severe late complications Six cases of the total material had hepatic tumours the incidence apparently being related to the amount of Thorotrast injected

ZUSAMMENFASSUNG

Es wird über eine Untersuchung berichtet die einen Teil eines Materiales von 1 000 Fällen umfasst denen während der Jahre 1932—1947 Thorotrastinjektionen verabreicht worden waren Besondere Beachtung wurden Malignitätserscheinungen und Folgezuständen nach extravasalen Thorotrastdepots gewidmet Etwa die Hälfte der Fälle mit extravasalen Depots entwickelten ernste Spätkomplikationen Sechs Fälle des ganzen Materiales hatten Lebertumore was offensichtlich mit der Menge des injicierten Thorotrasts zusammenhing

RÉSUMÉ

Les auteurs présentent une étude d une partie d un total d environ 1 000 sujets ayant subi une injection de Thorotrast dans les années 1932 à 1947 Ils ont recherché spécialement l apparition d affections malignes et les conséquences d injections extravasculaires de Thorotrast La moitié environ des sujets qui ont eu une injection extravasculaire ont présenté des complications tardives graves Six cas du nombre total de sujets ont eu des tumeurs hépatiques la fréquence de ces complications paraît liée à la quantité de Thorotrast injectée

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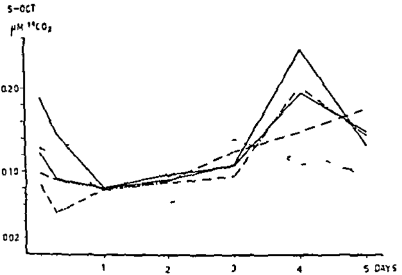


Diagram showing S OCT before and after the intravenous injection each line representing S OCT for one animal

0 3? g/kg bodyweight of Ph 761/3 (————)
0 94 g/bodyweight Biligrafin forte© (— — —)
2 ml physiologic saline per animal (– – – –)

in S—OCT The values in three of them were below 0 4 micromol the course of two of these is shown in the diagram above The activity in the fourth case rose to 0 610 micromol on the second day, this high value can hardly be regarded as normal, although the liver itself showed no gross changes at autopsy

The Biligrafin forte©, given to two of the controls, is known to have no deleterious action on the liver when low and moderate doses are employed The transferase activity after application of Biligrafin forte® was similar to that in the rabbits receiving Ph 761/3 or physiologic saline

No change in the enzyme activity was recorded when to exclude a direct action of the Ph 761/3 on the transferase activity increasing amounts of from 0 001 g to 0 01 g were added to serum with a high content of the enzyme

It seems justifiable to conclude from the above results that the Ph 761/3 did not cause any liver damage reflected in a pathological change in the transferase activity This is in agreement with the experiences of EDLUND & ZETTERGREN (1961) who found no histologically demonstrable changes in the liver on giving albino rats repeated doses of Ph 761/3 of up to 0 15 g/kg bodyweight

It is thus probable that the reduction in bile secretion observed in the previous study to follow the intravenous injection of Ph 761/3 was not a toxic effect but was due to a process that was the opposite of hydrocholeresis

This reduction in bile output suggested that Ph 761/3 or some of its possible metabolites might be toxic to the liver. The increase that occurs in toxic liver damage in the activity in the serum of ornithine carbamoyl transferase (S—OCT), an enzyme occurring almost exclusively in the liver, provides a sensitive and specific indication of such injury (REICHARD 1959).

S—OCT was followed after the administration of different amounts of biliary contrast medium in order to investigate whether the reduction in the bile output following the injection of the Ph 761/3 might have a toxic origin.

Material and Method. The experiments were performed in rabbits of both sexes weighing from 1.7 to 4.2 kg. The intravenous injection and the withdrawal of blood samples were performed without anaesthesia.

Five rabbits were each given 0.11 g and six rabbits 0.32 g/kg bodyweight intravenously of Ph 761/3. Six further rabbits served as controls, four of them each receiving 2 ml physiologic saline and two of them 0.94 g/kg bodyweight of Biligrafin forte®. Blood samples were taken before the injections, 4 hours afterwards and then daily for 2 to 5 days. The samples were centrifuged and the serum stored at —20° C until the S—OCT was determined. The animals were sacrificed after the last blood sample had been taken. The livers and kidneys were examined macroscopically.

The activity in the serum of ornithine carbomoyl transferase was determined by the method of REICHARD & REICHARD (1958) under standard conditions. The activity is expressed in micromol of $^{14}CO_2$ in 0.5 ml serum.

Results and Discussion

The S—OCT prior to injection of the different substances did not in any of the 17 rabbits in the series exceed 0.4 micromol. The activity after the injection of Ph 761/3 and the two control substances varied individually and from day to day, but for only two animals did it exceed 0.4 micromol.

The S—OCT after the injection of Ph 761/3 was as follows. The enzyme activity in seven of the eleven rabbits fell during the first 2 days and remained unchanged for 4 days. Four of the six rabbits that received 0.32 g Ph 761/3 were followed for 5 days. The daily fluctuation in enzyme activity in two of them was less than that in the animals that received 0.11 g (see Diagram), the values were highest on the fifth day of observation in the third case. The S—OCT was not higher than 0.4 micromol in any of these three rabbits and the course was largely the same as for the animals receiving physiologic saline. The activity in the fourth case rose above 0.4 micromol and the course deviated widely from that recorded for the other animals. It was found at autopsy that the liver was the site of a parasitic disease and contained numerous white nodules.

The four animals receiving physiologic saline also showed a daily varia-

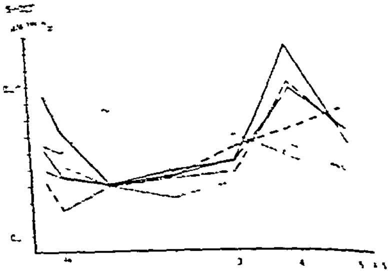


Diagram showing S-OCT before and after the intravenous injection, each line representing S-OCT for one animal.

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FROM THE ROENTGENDIAGNOSTIC DEPARTMENT (DIRECTOR PROF OLLE OLSSON), UNIVERSITY HOSPITAL, LUND, SWEDEN

INCOMPLETE ANGIOGRAM IN SELECTIVE RENAL ANGIOGRAPHY

by

ROLF KÖHLER

It is our practice to perform primary aortic renal angiography only (1) in cases of hydronephrosis and malformation owing to the frequency of multiple renal arteries in these conditions, (2) in cases in which a direct comparison between the two renal arteries is desirable, for instance to estimate potential renal function, (3) as a complementary measure in examinations *in which it* is important to demonstrate the origin of the renal artery as in hypertensive disease

The majority of renal angiographies are consequently performed by the selective technique The present investigation was concerned with incomplete contrast filling of the kidney *following* separate injection of contrast medium i. to one of multiple renal arteries or in a branch of a single artery

Earlier investigations The literature contains very little on the problems involved It has been stated that at catheterization of a kidney with multiple arteries the unfilled region may be mistaken for an avascular tumor (EDHOLM & SELDINGER 1956 OLLE OLSSON *1962*) *Boijsen* (1959) however pointed out that such a defect in the angiogram may readily be distinguished from a tumor

Submitted for publication 11 April 1962

SUMMARY

A study in 11 rabbits and 6 control animals of the effects of a biliary contrast medium (tetra iodophthalic acid morpholide) on the liver by determining the serum ornithine carbamoyl transferase activity a sensitive and early indicator of liver damage is described The reduction in the bile secretion with this contrast medium reported in a previous communication would appear to have been due to a process that was the opposite of hydrocholeresis and thus not to a toxic effect

ZUSAMMENFASSUNG

Experimente uber die Wirkung von Gallenkontrastmittel (tetra iodophthalic acid morpholide) auf die Leber wurden mit Hilfe der Serum-ornithine-carbamoyl Transferase Aktivitätsmessung an 11 Kaninchen und 6 Kontrolltieren angestellt Die Transferase Aktivitätsmessung ist eine besonders empfindliche Methode für die Feststellung von Leberschäden Die Verminderung der Gallenausscheidung nach Verabreichung des Kontrastmittels die schon in einer früheren Veröffentlichung beschrieben wurde scheint eine funktionelle Gegenwirkung der vermehrten Gallenausscheidung zu sein und nicht ein Zeichen von Leberschädigung

RÉSUMÉ

Les auteurs présentent une étude faite sur 11 lapins et 6 animaux témoins des effets sur le foie d un moyen de contraste biliaire (morpholide de l acide tétra iodophtalique) par la mesure de l activité de transférase de l ornithine carbamoyl sérique qui est un indicateur sensible et précoce des lésions hépatiques La réduction de la sécrétion biliaire sous l effet de ce moyen de contraste signalée dans un travail précédent semble être due à un processus inverse de l hydrocholérèse et non à un effet toxique

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SKACTUS K Personal communication

A ventral and a dorsal region of supply were recognized these being located in the pars intermedia and from which the ventral and dorsal arteries extend their supply in both a cranial and caudal direction The dorsal artery runs predominantly in a cranial direction so that the ventral pyramids (pyr 1—2 V) are also encompassed the ventral artery runs mostly in a caudal direction so that the dorsal pyramids in the pars inferior of the kidney (pyr 6—7 D) are also supplied It was shown that in about 60 of all cases the pars inferior i e that part of the kidney usually resected is supplied by a single artery

Multiple arteries are said to be present when the kidney is supplied by more than one artery from the aorta or a common iliac artery and the term is used when reference is made to the entire supply to the kidney Any other than the main renal artery arising from the aorta or a common iliac artery is called a supplementary artery

Arteries of this type may be identified in a good 20 % of the cases in a clinical series (EDSMAN 1957 BOIJSEN 1959) and there is one supplementary artery in over 90 per cent of cases These vessels are segmental like the other renal arteries and correspond to the branches of a single renal artery Of 134 kidneys in which one supplementary artery was observed, this artery supplied the pyramids in the pars inferior in 71 %, the pyramids in the pyr 1—2 VD segment in 13 % and the pyramids within the supply of the dorsal artery (pyr 3—5D) in 11 % the supplementary artery supplied pyramids in the ventral midportion of the kidney (pyr 3—5 V) in the remaining 5 %

Incomplete filling is obtained in cases of multiple renal arteries with selective injection of contrast medium either into the supplementary artery or the main renal artery The same may happen in early origins of the main branches from a single artery these were observed by BOIJSEN in 7 % of cases Incomplete filling of the kidney is thus usually due to purely anatomical factors The catheterization technique however, may also sometimes be responsible for instance the tip of the catheter may be pushed too far into a single renal artery in a selective investigation with the result that only one usually the ventral branch is injected

Material The series under examination consists of 41 kidneys in 40 cases with incomplete angiograms in selective renal angiography out of several hundreds of such examinations *In 23 of these cases contrast medium was also* injected into the aorta to fill the kidney completely with contrast medium

The supply of the supplementary arteries varied as follows Right kidney pars superior 1 case pars intermedia 1 case pars inferior 13 cases inferior and intermedia 3 cases Left kidney pars intermedia 2 cases pars inferior 6 cases superior and intermedia 2 cases inferior and intermedia 3 cases Two supplementary arteries were encountered in one case in which the main artery supplied principally the dorsal segments In six cases the dorsal and ventral arteries arose separately from the aorta Besides these cases the series included 3 cases with incomplete filling within the distribution of a single renal artery

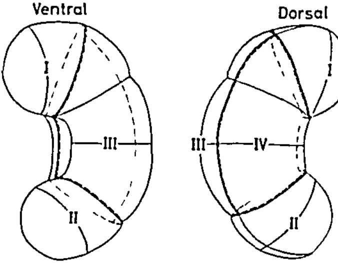


Fig 1 Diagram of left kidney showing the four arterial segments I — pyr 1—2 VD II — pyr 6—7 VD III — pyr 3—5 V IV — pyr 3—5 D (After Boijsen 1959)

The incomplete angiogram is strictly related to the vascular anatomy The following scheme of the arterial supply of the kidney was introduced by Boijsen (1959) in his comprehensive angiographic studies of the anatomy of single and multiple renal arteries

The renal artery is so termed until it branches into the dorsal artery and the ventral artery which are primary branches and lie dorsal and ventral to the renal pelvis. Further primary branches are also given off to different parts of the kidney most frequently to the poles before the division or together with the dorsal artery to form a tri or quadrifurcation. The dorsal and ventral primary branches give off secondary branches (dorsal as well as ventral) All the secondary branches are segmental arteries since they supply only certain limited parts of the renal parenchyma Segmental arteries further divide into subsegmental arteries which supply portions of a segment e g r dors pyr 5 D These subsegmental arteries may also arise directly from the primary arteries or from the renal artery

The interlobar arteries which enter the parenchyma between two pyramids, arise from the subsegmental arteries in the sinus.

Boijsen in an investigation based on the fundamental work on the topographic arrangement of the pyramids by Löfgren (1949) reported that the kidney has a segmental pattern that does not coincide with the borders of the lobes The kidney is made up of 7 pairs of pyramids, each pair consisting of a ventral (V) and a dorsal (D) pyramid (pyr) Four segments were described namely

I — The two most cranial pairs of pyramids (pyr 1—2 VD)
II — The two most caudal pairs of pyramids (pyr 6—7 VD)
III — The three middle ventral pyramids (pyr 3—5 V) and
IV — The three middle dorsal pyramids (pyr 3—5 D) (Fig 1)

A ventral and a dorsal region of supply were represented [illegible] intermedia and from which the ventral and dorsal arteries extend [illegible] cranial and caudal direction. The dorsal artery runs [illegible] the ventral pyramids (pyr. 1—2 V) are also encompassed [illegible] the ventral artery [illegible] in a caudal direction so that the dorsal pyramids in the pars inferior of [illegible] 6—7 D) are also supplied. It was shown that in about 60 [illegible] of all cases the [illegible] that part of the kidney usually resected is supplied by a single artery.

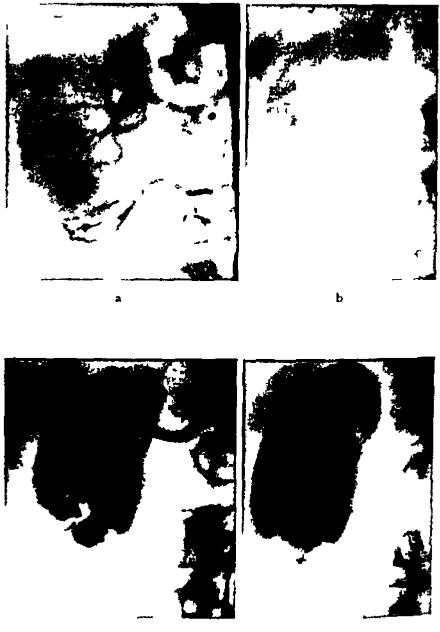
Multiple arteries are said to be present when the kidney is supplied [illegible] than one artery from the aorta or a common iliac artery, and the [illegible] used when reference is made to the entire supply to the kidney. Any [illegible] than the main renal artery arising from the aorta or a common iliac artery [illegible] called a supplementary artery.

Arteries of this type may be identified in a good 20 % of the cases in [illegible] ical series (EDSMAN 1957, BOIJSEN 1959) and there is one supplementary artery in over 90 per cent of cases. These vessels are segmental like the other renal arteries and correspond to the branches of a single renal artery. Of 134 kidneys in which one supplementary artery was observed this artery supplied the pyramids in the pars inferior in 71 %, the pyramids in the pyr. 1—2 V D segment in 13 % and the pyramids within the supply of the dorsal artery (pyr. 3—5D) in 11 %, the supplementary artery supplied pyramids in the ventral midportion of the kidney (pyr. 3—5 V) in the remaining 5 %.

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Material. The series under examination consists of 41 kidneys in 40 cases with incomplete angiograms in selective renal angiography out of several hundreds of such examinations. In 23 of these cases contrast medium was also injected into the aorta to fill the kidney completely with contrast medium.

The supply of the supplementary arteries varied as follows. Right kidney: pars superior 1 case, pars intermedia 1 case, pars inferior 13 cases, inferior and intermedia 3 cases. Left kidney: pars intermedia 2 cases, pars inferior 6 cases, superior and intermedia 2 cases, inferior and intermedia 3 cases. Two supplementary arteries were encountered in one case in which the main artery supplied principally the dorsal segments. In six cases the dorsal and ventral arteries arose separately from the aorta. Besides these cases the series included 3 cases with incomplete filling within the distribution of a single renal artery.



a b

c d

Fig. [illegible] a and b. Aortal angiography of the right kidney. A supplementary artery to the lower pole arises from the aorta 43 mm below the main artery. c and d. Selective angiography of the main artery, arterial phase. Arteries [illegible] filled. Nephrographic phase. Defect corresponding to the region of supply of the supplementary artery evident, the lower part of the renal pelvis marks a part of the nephrographic defect.



a



b



c

Fig 3 a) and b) Selective angiography of the main artery to the right kidney (right oblique). Vessels to p r 6— VD missing in the arterial phase corresponding defect in the nephrographic phase the irregular boundary line curves concentrically in cranial direction early origin of the artery which supplies the superior part of the upper pole of the kidney c) Aortic angiography demonstrating the supplementary artery

of the kidney This source of error is therefore unimportant in the evaluation of the vasculature of the kidney as a whole

Pars intermedia Three cases, one of which had a supplementary artery supplying pvr 3—4 V and the other two a supplementary artery of the type a ventr pvr 4—5 V, are included The main artery filled with contrast medium but vessels were missing ventrally in the pars intermedia A typical contrast defect with a somewhat irregular margin was evident laterally and ventrally at the corresponding site in the nephrographic phase

Pars inferior Supplementary arteries to the lower pole of the kidney were established in 19 of the 38 kidneys Fig 2 shows a hydronephrotic kidney with an artery to the lower part arising from the aorta 18 mm below the main artery The supplementary artery supplied pvr 6—7 VD At selective angiography of the main renal artery a contrast defect corresponding to the region of supply of the supplementary artery was demonstrated in the nephrographic phase The caudal end of the dilated renal pelvis containing contrast medium was projected onto this defect A corresponding finding is illustrated in Fig 3 Fig 4 is from a similar case in which a renal carcinoma with profuse pathologic vessels involved the superior part of the kidney The lower pole of the kidney was supplied by a supplementary artery to pvr 6—7 VD The boundary with the non filled lower pole was markedly irregular

A separate selective angiography of both the main artery and the supplementary artery to the right kidney is seen in Fig 5 The arterial supply to pvr 6—7 VD came from a relatively large polar artery which gave off the spermatic artery The remainder of the kidney was supplied by the main artery The boundary between the two renal sections was curved and in addition markedly irregular in the nephrographic phase The last mentioned feature was probably due to the contour forming character of the area supplied by the dorsal artery (see below) Frost (1962) in a description of a case of renal rupture has included two illustrations which suggest that it represents a normal roentgen anatomic appearance

Pars superior and intermedia was represented in two cases, both left sided In one of the cases the catheter first slid into a cranial supplementary artery (Fig [illegible] This artery supplied pvr 1—2 V of the upper renal pole and also pvr 3 V in the intermediate area A corresponding deposit of contrast medium in the kidney was evident in the nephrographic phase The catheter was then manipulated into the main artery and a further injection performed (Fig 7 a [illegible] b) the remaining areas of the kidney were then filled A third injection of contrast medium with the catheter in the aorta finally produced complete filling of both arteries (Fig 7c)



a b

Fig 6 Selective angiography of a supplementary artery to the left kidney a) Late arterial phase Arteries supply pyr 1—2 V and 5 V b) Wedge like deposit of contrast medium with the base cor tically in pyr 5 V marked nephrographic effect the caudal margin of which is characteristically con ex with small indentations in the upper pole

Pars inferior and intermedia were represented in three right and three left sided cases A right sided hydronephrotic kidney (Fig 8) had a supplementary artery to the lower pole of the kidney consisting of pyr 6—7 V and 5—7 D This artery was catheterized separately to obtain good filling of the correspond ing vein, the contrast filled part displayed an extremely irregular margin cra mally in the nephrographic phase

In one case (Fig 9) contrast medium was first injected into the main artery and disclosed a renal cyst in the upper pole Incomplete filling was evident in the lower pole due to a supplementary arterial supply The catheter was then introduced into the supplementary artery which supplied pyr 5 1/2—7 V and 6—7 D The nephrogram displayed a cranial contour of considerable irregularity, especially laterally because the supply to pyr 5 V was divided between the main and the supplementary artery One supplementary artery supplied pyr 5—7 V and 6—7 D (Fig 10) a somewhat diminished nephro graphic effect was observable within segment 5 owing to the asymmetric and purely ventral filling in this area The arterial system was completely filled by aortic angiography

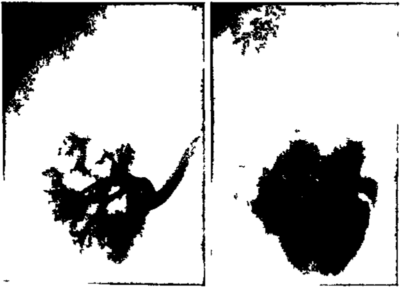
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Pars intermedia. Three cases, one of which had a supplementary artery supplying pyr. 3—4 V and the other two a supplementary artery of the type a. ventr. pyr. 4—5 V, are included. The main artery filled with contrast medium but vessels were missing ventrally in the pars intermedia. A typical contrast defect with a somewhat irregular margin was evident laterally and ventrally at the corresponding site in the nephrographic phase.

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A separate selective angiography of both the main artery and the supplementary artery to the right kidney is seen in Fig. 5. The arterial supply to pyr. 6—7 VD came from a relatively large polar artery which gave off the spermatic artery. The remainder of the kidney was supplied by the main artery. The boundary between the two renal sections was curved and in addition markedly irregular in the nephrographic phase. The last mentioned feature was probably due to the contour forming character of the area supplied by the dorsal artery (see below). FROST (1962) in a description of a case of renal rupture has included two illustrations which suggest that it represents a normal roentgen anatomic appearance.

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a b

Fig 8 Selective angiography of supplementary artery to the inferior part aa ventr pyr 6—7 V and dors pyr 5—7 D of a moderately hydronephrotic right kidney Markedly indented margin cranially in the nephrographic phase (b) indicating that the renal parenchyma supplied by the dorsal artery is contour forming

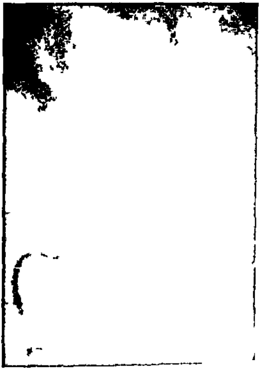
Dorsal and ventral arteries arising separately from the aorta These cases were 6 in number, all of them left sided and roentgenologically of similar and characteristic appearances Minor variations were established at the origins of the arteries at the aorta and in the segmental distribution between their branches

In one case (Fig 11) the dorsal branch and the ventral branch were catheterized separately, they arose from the aorta quite close to one another (Fig 11c) The supply of the dorsal artery (a dors pyr 1—2 V, 1—5 D) was clearly visible in the nephrogram (Fig 11b) the lateral and caudal contour being markedly irregular but nevertheless quite sharply defined The arterial distribution (a ventr pyr 3—7 V 6—7 D) established by injecting the ventral artery is evident in Fig 11c The nephrogram revealed sharp contours laterally and caudally Contrast defects corresponding to the dorsal segment were present cranio medially and centrally

Selective filling of the dorsal artery is demonstrated in Fig 12 The nephrographic deposit is concentrated in a cranial and a caudal area With the exception of the medial contour the margins of the filled areas are again extremely irregular The ventral artery was shown by cineradiography to arise from the aorta barely 1 cm below the dorsal artery



a



b



c

Fig. 7. Same case and same kidney as in fig. [illegible] a) and b). Selective angiography of the main artery. Other segments of the kidney now filled. c) Aortal renal angiography. Each arterial branch now filled with contrast medium.

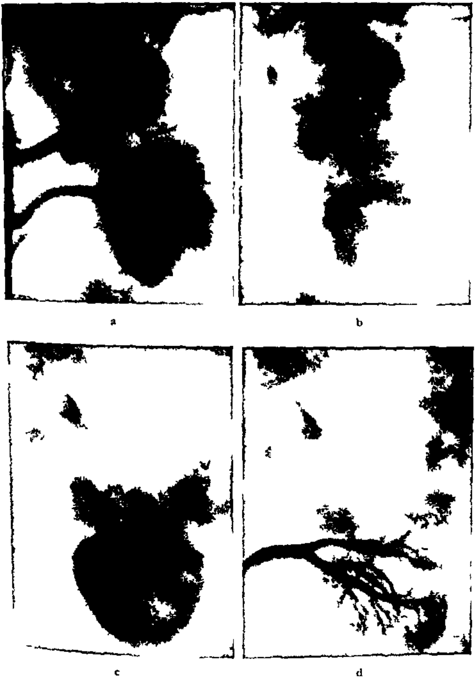
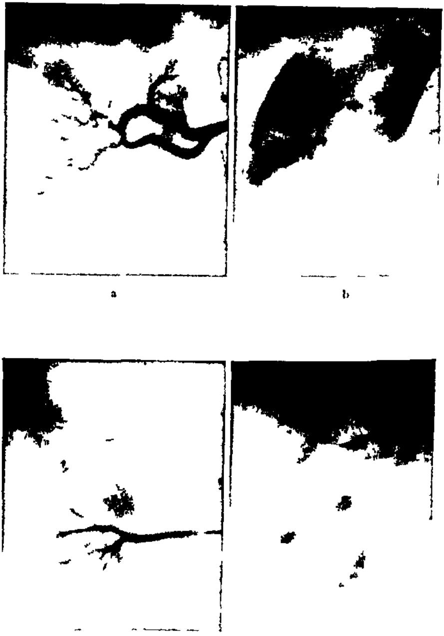


Fig 10 a) and b) Selective angiography of supplementary artery to left kidney supplying pyr 3—4 and 6—7 D Lower pole more filled with contrast medium than segment 5 owing to asymmetric and solely ventral supply of this area via the supplementary artery c) and d) Complete filling of the arterial system at aortal angiography



a b c d

Fig. 9. Selective angiography, right kidney. a. Main artery [illegible] arterial branches of the upper pole deviate around a cyst [illegible] of arteries in the lower [illegible] b. Nephrographic phase. The parenchyma is well filled to the sharply [illegible] cyst. Below, a contrast defect with irregular contour curves cranially [illegible] mentary artery contrast [illegible] field of supply [illegible] remaining nephrogram. Upward curving cranial contour marked [illegible] especially laterally because of divided arterial supply [illegible] upper half of nephrogram shows a stippled decrease in density [illegible]

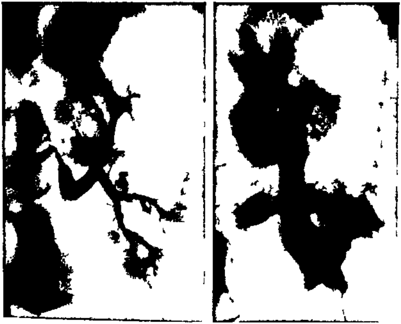
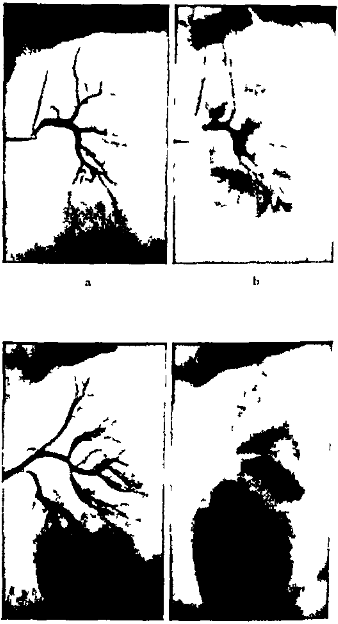


Fig 12 Selective angiography of a dorsal artery arising separately from the aorta pyr 1—7 D Considerable deposit of medium with irregular margins in the nephrographic phase Distinct renal vein

In Fig 13a is illustrated the appearance in selective filling of the dorsal artery With the exception of the medial renal contour the margin of the contrast loaded parenchyma is again irregular, and in the upper part of the kidney the arteries are curved and stretched around an oval clearly demarcated area, a renal cyst Aortal angiography (Fig 13b) revealed that the ventral artery emerged from the aorta 9 mm below the dorsal artery The cyst was hardly discernible The cyst was contrast filled by puncture and injection of contrast medium (Fig 13c)

Multiple arteries totalling 3 The series included a case in which the dorsal artery was catheterized selectively Three arteries could be demonstrated in the aortal angiogram Contrast medium was first injected into the dorsal artery (Fig 14a) The typical appearances were evident in the nephrographic phase The artery supplied pyr 1—2 V and 1—6 D The aortic examination (Fig 14b) showed that the dorsal artery was the largest vessel, branched off most cranially and could be regarded as a main artery the next in order was a lower pole artery, and the most caudal vessel was the ventral artery supplying pyr 3—6 V



a b

c d

Fig. 11 a) and b) Selective angiography of a d[illegible]sal artery ar[illegible] separately from the aorta a[illegible]d [illegible] 1—? V [illegible] 1—5 D. Irregular but nevertheless fairly sharp lateral and caudal contour area [illegible] the ventral segment. c) and d) Same kidney, selective catheterization of the ventral artery (a. ventr.) [illegible] 3—7 V [illegible] —7 D [illegible] filling of the dorsal artery proximally is evident also in the arterial phase. Medially and centrally the filling defect exactly corresponds to the dorsal segment.

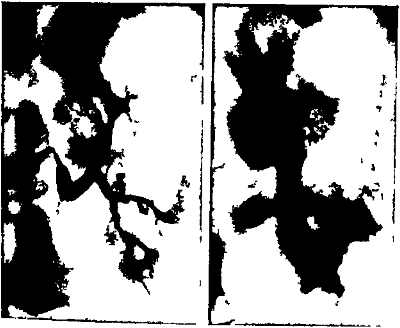
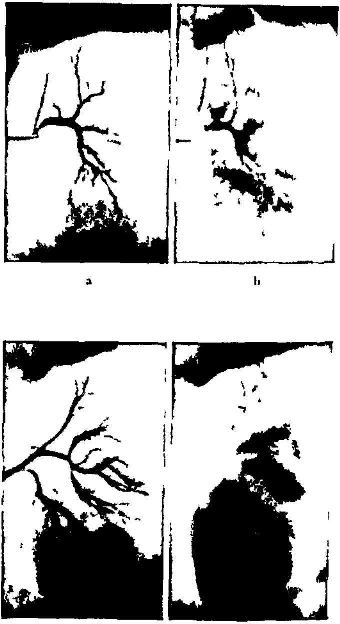


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a b

c d

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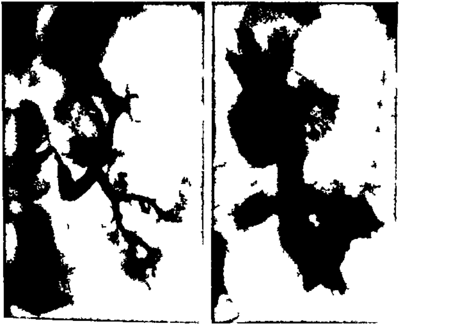


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a b



c d

[illegible] 1. Selecti[illegible] ang[illegible] [illegible] Arter[illegible] [illegible] [illegible] view. [illegible] the ventral artery [illegible] 3—7 [illegible] D [illegible] [illegible] phase [illegible] the [illegible] segment there [illegible] an irregular [illegible] segment 3 [illegible] with [illegible] contra[illegible] [illegible] [illegible] contrast [illegible] [illegible] artery [illegible] 1—7 [illegible] 1—3 D [illegible] filled with [illegible] defect [illegible]

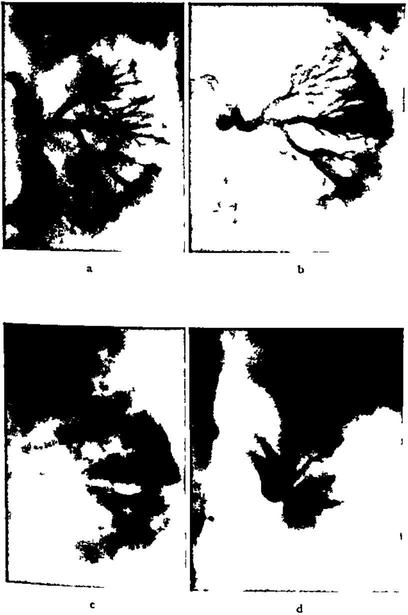


Fig 16 a) Selective angiography arterial phase Tip of catheter at about 1 cm depth in the ventral artery b) Late arterial phase Dorsal artery also moderately filled with surplus contrast medium supplies pyr 1—3 V and 7 V and pyr 1—7 D c) Nephrographic phase The segments of the kidney that are supplied by the ventral artery appear to contain most of the contrast medium d) Aortic angiography Dorsal artery arises from the renal artery about 1 cm to the left of the aorta density of medium is now the same in both the primary branches of the renal artery

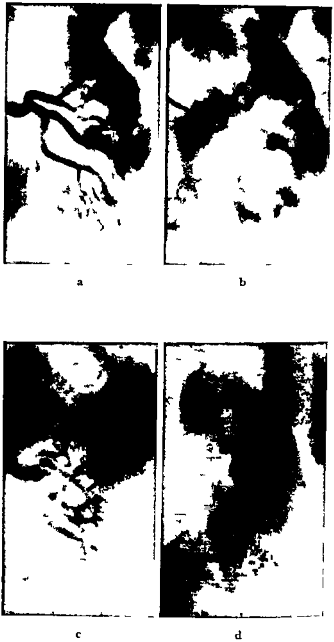


Fig 15 Selective angiography of left kidney a) Arterial phase frontal view Only the ventral artery a ventr pyr 3—7 V 6—7 D is filled b) Nephrographic phase No deposit of medium in the dorsal segment there is an irregular concave contour of segment 3 V with considerable contrast medium against the contrast free upper pole c) and d) Aortic angiography Dorsal artery a dors pyr 1—2 V 1—5 D is now filled with medium no defects evident

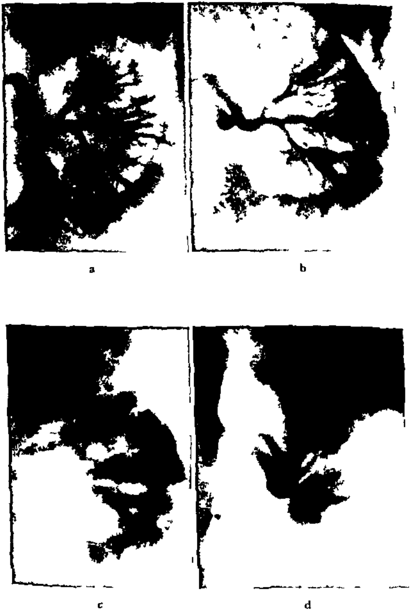


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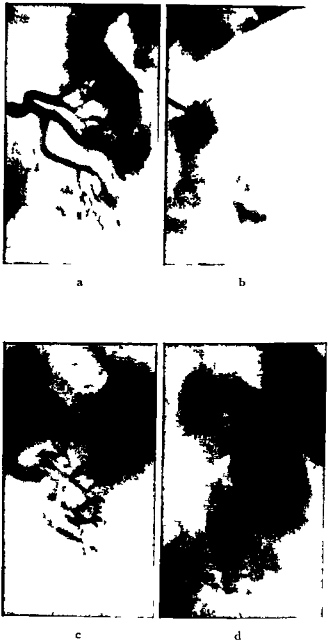


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The fields of supply of supplementary arteries are fairly uniform in the majority of the cases, and this applies especially to the lower pole of the kidney. A variable pyramid combination may, however be supplied by the same supplementary artery (Figs 6 and 9)

SUMMARY

Familiarity with the appearances of incomplete filling of the renal arteries is important in selective renal angiography. Incomplete filling may be caused by selective catheterization of one of multiple renal arteries a common anomaly or a branch of a single artery. The characteristic changes are described in detail

ZUSAMMENFASSUNG

Man muss mit dem Bild der unvollständigen Füllung der Nierenarterien bei der selektiven Nierenangiographie vertraut sein. Unvollständige Füllung kann erfolgen wenn mehrere Nierenarterien vorliegen — was häufig ist — oder wenn man in einen Zweig der Hauptarterie gerät. Die resultierenden Bilder werden im Einzelnen beschrieben

RÉSUMÉ

Il est important d être familiarisé avec les aspects de remplissage incomplet des artères rénales dans l angiographie rénale sélective. Le remplissage incomplet peut être du a la cathétérisation sélective d une artère parmi des artères rénales multiples anomalie fréquente ou d une branche d une artère unique. L auteur décrit en détail les images caractéristiques

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cause the catheter tip to lie in the ventral artery. The contrast medium initially flowed only into the ventral artery (Fig. 16); when an increasing amount of contrast medium entered the arterial system in the final phase of the injection, the surplus medium ran into the dorsal artery, the supply of which was faintly discernible in the nephrographic phase.

Discussion

Since an anomaly of the vascular anatomy of multiple renal arteries is evident in a good 20 % of all kidneys at selective renal angiography, the angiograms will often vary in appearance. Attention is attracted especially by defects in the nephrogram which are delineated by a curving and often very irregular contour. A roentgenologic finding of this type may suggest the presence of an expansive process or renal rupture.

It is necessary, in order to be able to interpret these cases correctly, to appreciate that the renal arteries including the supplementary arteries are end arteries, i.e. the various arterial branches each supply a portion of the kidney without interrelating anastomoses (SCHMAUS & HERXHEIMER 1932, PICK & ANSON 1940). The arterial fields of supply in the kidney are contiguous and unseparated by any intercalary zone (HOU JENSEN 1930, FUCHS 1931, LÖFGREN 1949).

Incomplete filling of the renal arterial system with contrast medium in the arterial phase of the angiography is capable in itself of revealing the occurrence of renal vascular anomalies. Still more obvious is the corresponding defect in the nephrogram. The boundary against this defect is always slightly curved and irregular, the latter appearance being due to the intricate contact between *the arterial supply areas. Nephrograms in which the dorsal artery* alone is filled are most characteristic, the contours of the area of supply in the renal parenchyma being irregularly demarcated (Figs. 7, 11, 12, 13, 14). These appearances may however also be observed when there is a deviation in the pattern of supply of the ventral artery (Fig. 9). These constant contour irregularities and defects are anomalies and are not caused by vascular contractions and ischaemia of an incidental functional nature. This investigation appears to account for the vascular contractions described by EDSMAN (1957).

The cortical defects would appear to arise from the absence of contrast medium in the most peripheral fields of supply of the ventral artery which is responsible for the main part (the lateral and caudal part) of the renal contour. Ischaemia in the lateral dorsal area is easily obscured by the total nephrographic effect inside the kidney, but may be revealed within the upper pole of the kidney and in the medial parts of the kidney where the supply of the dorsal artery is contour forming. A wedge like defect may be produced by contractions in a segmental or subsegmental artery, usually of ventral origin (cf. Fig. 6).

The fields of supply of supplementary arteries are fairly uniform in the majority of the cases, and this applies especially to the lower pole of the kidney. A variable pyramid combination may, however, be supplied by the same supplementary artery (Figs 6 and 9).

SUMMARY

Familiarity with the appearances of incomplete filling of the renal arteries is important in selective renal angiography. Incomplete filling may be caused by selective catheterization of one of multiple renal arteries, a common anomaly, or a branch of a single artery. The characteristic changes are described in detail.

ZUSAMMENFASSUNG

Man muss mit dem Bild der unvollständigen Füllung der Nierenarterien bei der selektiven Nierenangiographie vertraut sein. Unvollständige Füllung kann erfolgen, wenn mehrere Nierenarterien vorliegen — was häufig ist — oder wenn man in einen Zweig der Hauptarterie gerät. Die resultierenden Bilder werden im Einzelnen beschrieben.

RÉSUMÉ

Il est important d'être familiarisé avec les aspects de remplissage incomplet des artères rénales dans l'angiographie rénale sélective. Le remplissage incomplet peut être dû à la cathétérisation sélective d'une artère parmi des artères rénales multiples, anomalie fréquente, ou d'une branche d'une artère unique. L'auteur décrit en détail les images caractéristiques.

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FROM THE ROENTGENDIAGNOSTIC DEPARTMENT (DIRECTOR PROF KNUT LINDBLOM), KAROLINSKA SJUKHUSET, STOCKHOLM, SWEDEN

RESPIRATORY KYMOGRAPHY IN ACUTE PULMONARY DISEASE

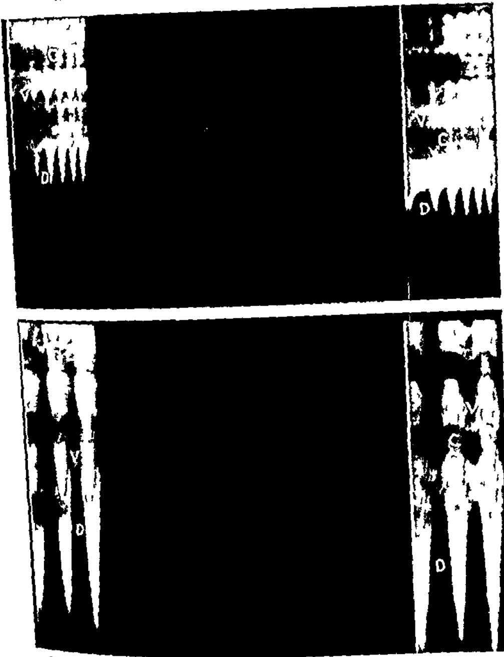
by

SAM SCHMIDT

Pathologic conditions of the chest and abdomen may influence the respiratory movements of the diaphragm and ribs the objective study of which may be effected by roentgen kymography The results of kymographic examinations of the diaphragm and ribs in various acute abdominal conditions were reported in an earlier paper (SCHMIDT 1960) Respiratory kymographic investigations in various acute pulmonary diseases form the subject of the present investigation

The literature on kymography in acute lung disease is scarce DAHM (1933) described a step form diaphragmatic respiration wave in a case of diaphragmatic pleuritis EPSTEIN (1955) published 50 cases of pleural effusion of varying etiologic origin and 10 cases of pneumonia in which kymography was performed This author stated that there was no restriction of movement or change in waveform of the diaphragm EPSTEIN performed his examinations in ordinary breathing only HAUBRICH (1956) in his book stated that restriction of the movement of the diaphragm on the affected side generally occurs in pneumonia Paralysis of the diaphragm may be present, and, according to HITZENBERGER (1928), due to structural changes caused by extension of the infection Costal respiratory movements are not mentioned by any of these authors

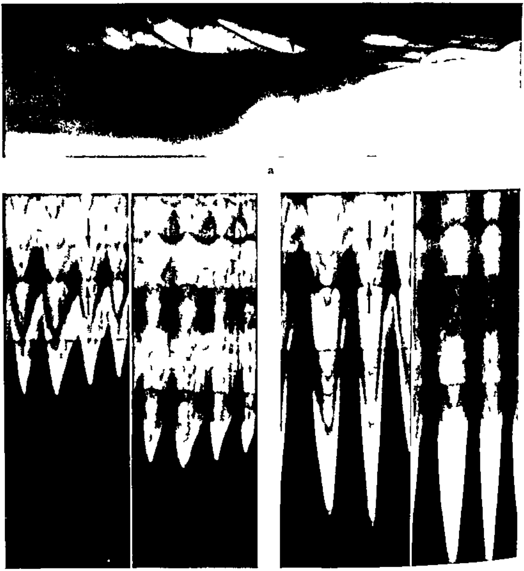
Submitted for publication 27 March 1962



Right side | Left side

Fig. 1. Normal kymographic appearances: ordinary respiration (upper) and deep respiration (*lower*). D — diaphragmatic movement wave. C — costal movement wave. V — movement wave of pulmonary vessels.

These are reproductions of the original 30 × 40 cm films. In the subsequent illustrations the tracings of the right and left sides are placed close together to save space.



a b c

Fig 2 Right pleural effusion no parenchymatous changes a) Right decubitus b) and c) Respiratory kymography in ordinary and deep respiration normal waveform normal amplitude of diaphragmatic waves bilaterally and of costal waves on the left side Markedly reduced amplitude of costal waves on the affected right side (arrows)

Technique The apparatus and technique were the same as those used in the earlier investigation on acute abdominal conditions (SCHMIDT 1960) The examinations were performed with the patient supine and the roentgen tube

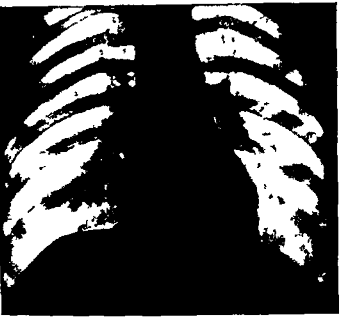
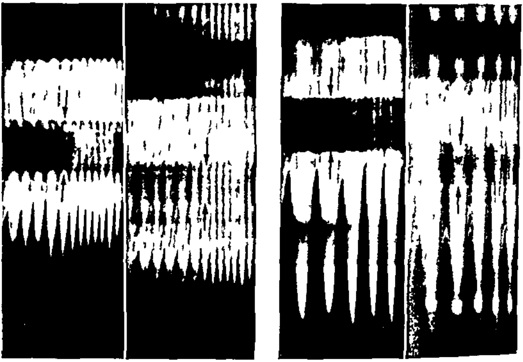


Fig 3 Bronchopneumonia left base no pleural effusion

below the table The kymograph, supported on legs and placed above, is fitted with two movable lead plates each with a 1 mm slit Each of the plates, under fluoroscopic control, is so arranged over one side of the diaphragm and lower half of the chest that the slit lies parallel to the long axis of the body and about 2 to 4 cm medial to the lateral thoracic wall A tray containing a 30 × 40 cm film lies above the plates Exposure factors 100 to 110 kV, 10 mA, and 10 to 20 seconds The film moves a distance of 5 5 cm during the exposure and a movement of a 1 mm broad segment of the diaphragm and the lower half of the chest is recorded on each side The movements of the posterior parts of the 7th to the 10th ribs are usually recorded The movements of the anterior parts of the ribs are also sometimes demonstrated The description which follows refers only to the posterior parts of the ribs Two films are exposed, one during ordinary and one during deep respiration

Normal kymographic appearances and physiologic considerations The normal kymographic tracing of a diaphragmatic respiratory cycle is a regular slightly asymmetric steep wave The ascending or expiratory limb is straight except for its upper end which is slightly curved, indicating some slowing down towards the end of the expiration The descending or inspiratory limb forms a straight line The apex of the wave (transition from expiration to inspiration) is a sharply pointed angle The average amplitude is 2 cm in ordinary and 4 5 cm in deep breathing



a b

Fig 4 Same case as in fig 3 Kymography in ordinary (a) and deep (b) respiration Normal waveform, moderately reduced diaphragmatic amplitude on the affected left side Markedly reduced amplitude of costal waves bilaterally (arrows) Increased respiratory frequency

The normal tracing of a costal respiratory cycle is a regular, more or less asymmetric undulating and relatively flat wave, whose direction is opposed to that of the diaphragmatic wave The average amplitude is 2 mm in ordinary and 5 mm in deep breathing Slight differences in the diaphragmatic and costal amplitudes occur on the two sides in normal cases, the individual differences are greater

The amplitudes of the respiratory movements refer in this paper to deep respiration and are classified as follows

1 Diaphragmatic amplitude		*2 Costal amplitude*	
Normal	4 to 5 cm	Normal	4 to 6 mm
Slightly or moderately reduced	2 5 to 3 5 cm	Slightly or moderately reduced	2 to 3 mm
Markedly reduced	< 2 cm	Markedly reduced	< 2 mm
Increased	> 6 cm	Increased	> 7 mm

The purpose of exposing two films, one during ordinary and one during deep respiration, is that the two tracings often show *different* wave patterns in addition to different amplitudes Deep respiration may be considered as a functional test

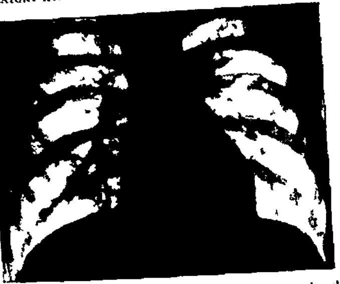


Fig 5 Minor bronchopneumonia right middle lobe no pleural effusion

According to anatomical studies performed by ASCHOFF and physiologic investigations by ARTHUR KEITH (1909), respiratory mechanics are composed of two separate anatomical and functional complexes

1 The costosternal mechanism formed by the second, third, fourth and fifth ribs the function of which is the expansion of the upper lobes by elevating and enlarging the thorax

2 The costodiaphragmatic mechanism formed by the sixth, seventh, eighth ninth and tenth ribs and the diaphragm The function of this unit of which the diaphragm is the dominant factor, is the expansion of the lower lobe

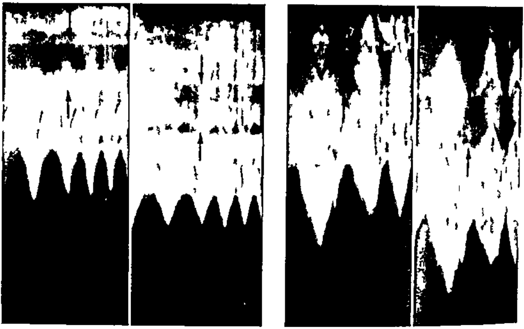
The sixth rib which marks the position of the interlobar fissure is the borderline between the two mechanisms

Kymographic investigations by WEBER (1936) have confirmed these observations

It is evident from the above that the present investigations mainly refer to the lower lobes

Material Forty seven acute pulmonary cases were examined by kymography

	Cases
Bronchopneumonia	31
Pleurisy	7
Pneumonia	4
Traumatic lung lesion	4
Pulmonary embolism	1
Total	47



a b

Fig 6 Same case as in fig 5 Kymography in ordinary (a) and deep (b) respiration Step-formed diaphragmatic waves with slightly reduced amplitude on both sides Normal waveform of costal movements with slightly reduced amplitude on the affected side and increased amplitude on the left side (arrows)

The process was unilateral in 42 of the cases in 25 it was in the right lung and in 17 cases in the left lung The remaining 5 cases exhibited bilateral changes

The diagnoses were made by clinical and roentgenographic means The ages of the subjects varied from 17 to 77 years, and the length of the case histories from 8 hours to 2 weeks, the average being 2 to 3 days Of the cases with parenchymatous pulmonary changes only those in which they were situated in the lower half of the lungs have been selected Post operative pulmonary complications are not included in this material

Results

Diaphragmatic movements The form of the diaphragmatic movement waves was bilaterally normal in 27 cases (Figs 2, 4 and 9) The form was bilaterally abnormal in 17 cases and abnormal only on the affected side in 3 cases In 19 of the cases, the abnormality of the waves was due to one or more short inspiratory movements or, less often to a short standstill period during the expiration phase In 2 cases a similar irregularity was even present during

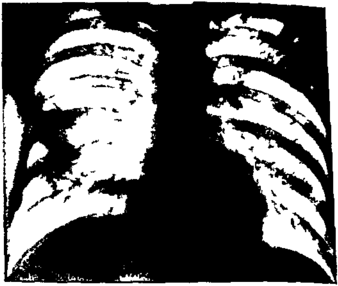


Fig 7 Pneumonia right middle lobe no pleural effusion

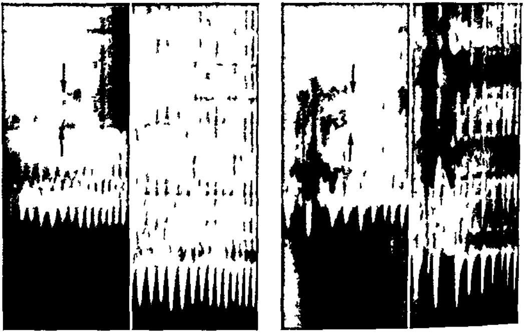
the inspiration phase As a result, the expiration limb (and sometimes the inspiration limb as well) was more or less step formed (Figs 6 8 and 10)

The diaphragmatic waves were bilaterally plateau shaped i e the apex was blunted instead of being sharp pointed in the remaining case (Fig 11) The blunted apex represents a short standstill of the diaphragm at the end of expiration This was a case of bronchopneumonia and acute nephritis

Of 27 cases with a unilateral process the amplitude of the diaphragmatic movements was about average on both sides in 11 cases (Figs 2 9 and 10), slightly or moderately reduced in 13 (Figs 4, 6 and 11) and markedly reduced in 3 cases (Fig 8) Of the remaining 15 cases with a unilateral process the diaphragmatic amplitude was slightly or moderately reduced on the affected side in 12 cases, markedly reduced in 2 and paradoxical in 1 case The amplitude was normal on the contralateral side in 11 cases moderately reduced in 2, and increased in 2 cases

In 5 cases with bilateral processes the diaphragmatic amplitude was slightly or moderately reduced on both sides in 4 cases in one case the amplitude was moderately reduced on the right side and markedly reduced on the left side

Costal movements Irregularities or other changes in the form of the costal movement waves are often difficult to assess due to the small amplitude and superimposed structures However in 5 cases with step-formed diaphrag waves the costal waves were also irregular bilaterally and in 3 cases unilat (Fig 8) In the remaining cases the waveform was normal



a b

Fig 8 Same case as in fig 7 Kymography in ordinary (a) and deep (b) respiration Irregular step-formed diaphragmatic waves in the deep breathing kymogram with markedly reduced amplitude particularly on the affected right side (arrows) Irregular costal waves with reduced amplitude most on the right side (arrows) Increased respiratory frequency

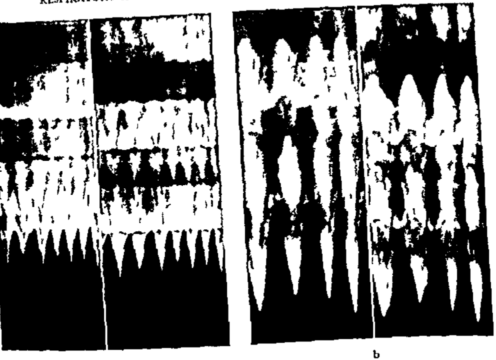
In 42 cases with unilateral changes, the costal amplitude was on the affected side an average in 7 cases, slightly or moderately reduced in 21 (Fig 6) markedly reduced in 9 (Figs 2 and 4), and increased in 3 cases (Fig 11) The ribs were immobile in 2 cases The amplitude on the contralateral side was as follows average in 19 cases (Fig 2), slightly or moderately reduced in 6 (Fig 8) markedly reduced in 8 (Fig 4), and increased in 9 cases (Figs 6, 10 and 11)

In the 5 cases with bilateral processes the costal amplitude was an average on both sides in 2 cases, and in one case moderately reduced on one side and increased on the other side The ribs showed no appreciable movements in 2 cases

No obvious differences in the waveform or amplitude of the diaphragmatic and costal respiratory movements were observed in the various acute lung conditions, and this was true whether a pleural effusion was present or not

An increase in costal amplitude often accompanied reduced diaphragmatic amplitude and/or reduced costal amplitude on the contralateral side

Pulmonary vessels and pathologic densities in the lower parts of the lungs followed the movements of the diaphragm in direction and amplitude



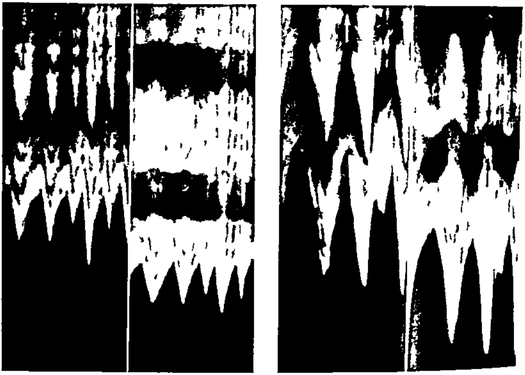
a b

Fig 9 Same case as in figs 7 and 8 three weeks later freedom from symptoms Kymography in ordinary (a) and deep (b) breathing Normal form and amplitude of diaphragmatic and costal waves

Discussion and Conclusions

The form of the diaphragmatic waves was normal in the majority of the cases and in over a third of the cases the wave was in step form bilaterally, indicating some disturbance in the respiratory mechanics, mostly during expiration Such a wave also occurs in other pulmonary diseases and even in abdominal conditions Diaphragmatic plateau waves with moderately reduced amplitude suggesting peritoneal involvement were observed in a case of bronchopneumonia and acute nephritis Plateau shaped waves were described in an earlier paper (SCHMIDT 1960) as appearing in some severe abdominal conditions and indicating peritonitis when associated with considerably reduced amplitude

The amplitude of the diaphragmatic breathing was in the majority of cases slightly or moderately reduced and only in 6 cases markedly reduced In two thirds of the cases the amplitudes were equal on both sides and in the remaining cases the difference of amplitudes between the affected and the other side was small The side of more reduced amplitude corresponded to the side of the pulmonary process Paradoxical diaphragmatic movements indicating



a b

Fig 10 Bronchopneumonia at right base after trauma of the chest no pleural effusion Kymography in ordinary (a) and deep (b) respiration Slightly step-formed diaphragmatic waves in the deep breathing kymogram with normal amplitude bilaterally Normal costal waveform with reduced amplitude on the affected right side and increased amplitude on the left side (arrows)

paralysis on the affected side in one case of basal bronchopneumonia suggested extension of the infection to the diaphragm

The form of the costal movement waves did not always follow that of the diaphragmatic waves but, as stated above, was often difficult to assess The amplitude of the costal movements on the affected side was in more than two-thirds of the cases slightly to considerably reduced The amplitude was an average, or increased, on the contralateral side in about two-thirds of the cases

It would thus appear that acute pulmonary diseases do not generally affect the form of the diaphragmatic or costal movement wave but in any event only in an unspecific way

The amplitude of the diaphragmatic movements is generally slightly or moderately reduced with little or no difference between the two sides Diaphragmatic paralysis is rare The amplitude of the costal respiration is usually reduced on the affected side and sometimes also on the contralateral side

Restriction of respiratory movements in a lung which is the site of an inflammatory or other process may be explained by reflex guarding during

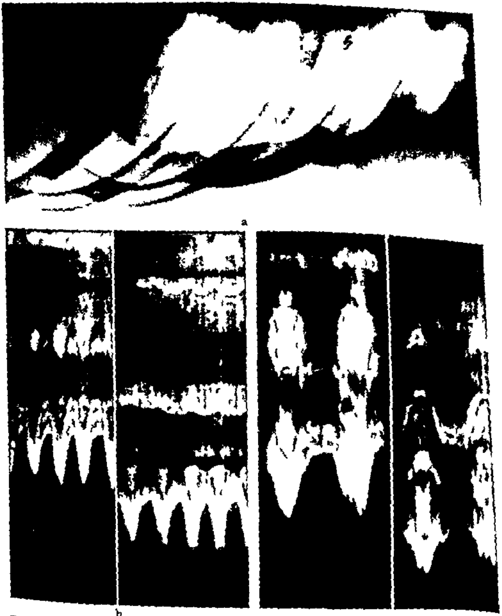


Fig 11 Bronchopneumonia left base with minor pleural effusion and acute nephritis (a) Left decubitus (b) and (c) Kymography in ordinary and deep respiration Plateau shaped diaphragmatic waves with moderately reduced amplitude in the deep breathing kymogram (arrows) Normal costal waveform with increased amplitude on both sides

painful breathing and by reduced compliance The diaphragmatic guarding appears to be less marked and less likely to be limited to one side in acute pulmonary disease as compared with acute abdominal conditions

SUMMARY

Respiratory kymographic studies of the diaphragmatic and costal movements in 47 cases of acute pulmonary disease are described Restriction of the costal respiratory movements on the affected side is predominant as compared with restriction of the diaphragmatic movements which is less marked and less often unilateral

ZUSAMMENFASSUNG

Respiratorische kymographische Studien der Zwerchfell und Rippenbewegungen in 47 Fallen von akuten Lungen Erkrankungen werden beschrieben Eine Einschrankung der respiratorischen Bewegungen der Ribben an der befallenen Seite ist vorherrschend im Vergleich mit der Einschrankung der Zwerchfell Bewegungen welche weniger ausgesprochen und auch in geringerem Masse einseitig ist

RÉSUMÉ

L auteur présente les résultats d examens kymographiques des mouvements respiratoires du diaphragme et des cotes dans 47 cas de maladies aigues des poumons La réduction des *mouvements respiratoires costaux du coté malade est predominante en comparaison* avec la diminution des mouvements diaphragmatiques qui est moins prononcée et moins souvent unilatérale.

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Fasc 5	DIAGNOSIS	September

INFLUENCE OF HEAVY CONTRAST MEDIA ON THE DEMONSTRATION OF HIATUS HERNIA AND GASTRO OESOPHAGEAL REFLUX

by

STIG SANDMARK

The contents of the peritoneal cavity consist largely of mobile organs which with the body in the erect position tend to fall away from the diaphragm and, with the pelvis raised to move towards the diaphragm The abdominal viscera are of approximately uniform density (1 03 to 1 06 g/cm³) (SCHAFER & THANE 1898) MARCHAND (1957), who made simultaneous recordings of the intra rectal, intravesical intraperitoneal and intragastric pressures under various conditions found that the recordings although differing in level bore the same relationship, the pressure being lowest in that part of the cavity which happened to be uppermost and to increase progressively downwards

The density of the contents of the digestive tract is largely the same as that of water The pressure difference between two points in a liquid the hydro static pressure, is only a question of difference in height between the points h the density of the liquid ϱ and the acceleration in a free fall g The pressure difference may be written $P = h\ \varrho\ g$

The hydrostatic pressure on the inner surface of the wall of a given gas free segment of the intestine or area of the stomach is thus the same as that acting on the outer surface

From the Department of Otolaryngology (Director Prof Hj Koch) and the Roentgendiagnostic Department (Director Prof O Olsson) University Hospital Lund Sweden

Based on paper read before the Nordic Society of Radiology June 1961 Submitted for publication 29 January 1962

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INFLUENCE OF HEAVY CONTRAST MEDIA ON THE DEMONSTRATION OF HIATUS HERNIA AND GASTRO-OESOPHAGEAL REFLUX

by

STIG SANDMARK

The contents of the peritoneal cavity consist largely of mobile organs which, with the body in the erect position, tend to fall away from the diaphragm and, with the pelvis raised, to move towards the diaphragm. The abdominal viscera are of approximately uniform density (1.03 to 1.06 g/cm³) (SCHAFER & THANE 1898). MARCHAND (1957), who made simultaneous recordings of the intrarectal, intravesical, intraperitoneal and intragastric pressures under various conditions, found that the recordings, although differing in level, bore the same relationship, the pressure being lowest in that part of the cavity which happened to be uppermost and to increase progressively downwards.

The density of the contents of the digestive tract is largely the same as that of water. The pressure difference between two points in a liquid, the hydrostatic pressure, is only a question of difference in height between the points, h, the density of the liquid, ϱ, and the acceleration in a free fall, g. The pressure difference may be written $P = h \cdot \varrho \cdot g$.

The hydrostatic pressure on the inner surface of the wall of a given gas-free segment of the intestine or area of the stomach is thus the same as that acting on the outer surface.

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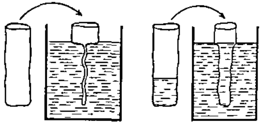


Fig 1 *Left* Air filled bag immersed in an open container filled with water by which it is compressed *Right* Bag partly filled with water and immersed in water The water levels inside and outside the bag are the same

A roentgen examination for hiatus hernia or gastro oesophageal reflux is usually made with a heavy contrast medium Since the physical density of such a suspension (1 4 to 2 g/cm³) is higher than that of ordinary food the hydrostatic pressure in the stomach after a meal of heavy contrast medium is necessarily also higher The density of the contrast medium should from a physiologic point of view, preferably be the same as that of the contents of the digestive tract

The stomach can receive comparatively large quantities of material without any significant rise in intraluminal pressure The pressure produced by gastric muscle tone following ingestion of a meal is normally in the region of 0 5 cm of water Gastric peristaltic waves produce higher pressures (QUIGLEY & BRODY 1950) Thus, as far as the present investigation is concerned the intragastric pressure (P_g) following a meal is largely the same as that recorded at a corresponding level in the peritoneal cavity (P_p) The intra oesophageal pressure (P_{oe}) is normally the same as the intrapleural pressure (P_{pl}), except in the supine position when P is slightly greater than P_{pl} owing to the weight of the overlying mediastinal structures (MEAD & GAENSLER 1959, FERRIS MEAD & FRANK 1959) Oesophageal peristaltic waves produce wide fluctuations in the intra oesophageal pressure (CODE, CREAMER, SCHLEGEL, OLSEN, DONOGHUE & ANDERSEN 1958)

Hiatus herniation is due to the difference between the intraperitoneal and the intrapleural pressures (P_{pe}—P_{pl}), gastro oesophageal reflux is caused by the difference between the intragastric and intra oesophageal pressures (P_g—P_{oe}) Neither herniation nor regurgitation can occur in the absence of such differences in pressure (MARCHAND 1957)

Thin walled bags of flexible, non expansible nylon were filled to varying levels with liquids of different densities and partly immersed in water The mouths of the bags were not closed

Influence of the hydrostatic pressure of surrounding water in model experiments

1 *Air in bag* The bag was compressed by the water (Fig 1 left)

2 *Water in bag* The level of the water was the same inside and outside the bag The more the bag was lowered the more it decreased in size owing to

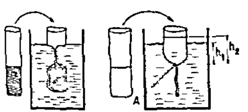


Fig 2 *Left* Bag partly filled with a liquid heavier than water (density ϱ_k) immersed in water the heavy liquid fills the lower part of the bag the rest of which under water is compressed *Right* Bag partly filled with a liquid lighter than water (density ϱ) immersed in water The lighter liquid fills the upper part of the bag and its level lies higher than that of the water The lower part of the bag is compressed Density of water $= \varrho$ (h_1 h = height)

compression by the water outside, but the level of the water was the same inside and outside the bag since the hydrostatic pressures were the same (Fig 1 right)

3 *Heavy fluid (barium contrast medium) in bag* Since the density of the fluid inside the bag was higher than that of water, the fluid remained at the bottom of the bag unaffected by the depth to which the bag was submerged That part of the bag above the heavy liquid was compressed by the hydrostatic pressure of the surrounding water (Fig 2 left)

4 *Bag filled with light fluid (oil)* Since the density of oil is lower than that of water the level of the former was always a little higher than that of the water (Fig 2 right) The lower part of the bag was compressed by the hydrostatic pressure of the surrounding water The difference between the level of the oil and that of the water remained unchanged by the depth to which the bag was submerged This equilibrium implies that the pressures acting within and outside the bag are equal at A in Fig 2 right i e P_i (pressure in bag) $=$ P (pressure in cavity) and thus $h_2\ \varrho_1\ g = h_1\ \varrho_w\ g$ Above that level $P_b > P$ and the bag is consequently distended Below A in the figure the bag is compressed by the hydrostatic pressure of the water

Influence of increased pressure within a closed cavity

A bag was lowered through an opening in the top of a perspex container The mouth of the bag was made water tight at the edges of the opening the bag was then partly filled with a liquid and the container was completely filled with water One wall of the container was made of rubber which could be pressed inwards to increase the pressure within the closed cavity

1 *Water in the bag* The level of the water was the same inside and outside the bag When the pressure within the container was increased by application of a force F, the bag was compressed and the level of the water in the bag rose in proportion to the increase in pressure (Fig 3) The force F increased the pressure inside the cavity by $\triangle$ P The pressure at A P $= h_1\ \varrho_w\ g + \triangle P$, $P_b = (h_1 + h_2)\ \varrho_w\ g$ thus $\triangle P = h_2\ \varrho_w\ g$

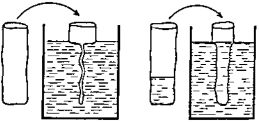


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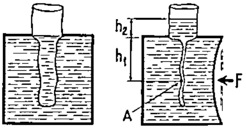
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Fig 3 Bag partly filled with water immersed in a container filled with water the wall of the bag is made watertight to an opening at the top of the container *Left* Surface of container exposed to atmosphere The levels of the water inside and outside the bag are the same *Right* Force F increases the pressure inside the container The bag is compressed and the water inside the bag rises Density of water = $\rho_w(h_1\ h_2$ – height)



2 *Heavy fluid (barium contrast medium) in bag* The heavy liquid filled the lower part of the bag and the upper part was compressed by the water Increase in the pressure inside the container produced no rise in the level of the heavy fluid in the bag but forced the walls of the bag up through the opening in the top of the container and thereby lifted the entire bag There was thus a herniation but no contrast medium came up into the hernia and no reflux occurred The larger the amount of fluid in the bag the higher the pressure necessary to lift it and not until the bag was filled with the heavy fluid to such a high level that the neck of the bag could not be closed by compression was it possible to raise the level of the liquid in the bag by application of pressure Fig 4 shows that the force F gives a pressure $\triangle$P that is propagated equally to all parts of the liquid (Pascal s principle) and also to the heavy liquid immersed If the neck of the bag is compressed and thereby sealed the equilibrium between the two liquids cannot be changed On application of force F, the weakest part of the closed container i e the wall of the unfilled part of the bag will therefore yield to the increased pressure and be forced up through the opening in the top of the container The pressure necessary to close the bag depends on the physical properties of the wall of the bag as well as on the viscosity of the heavy liquid and its adhesion to the walls of its container The compression is $= h_1\ \varrho_w\ g$ at A in Fig 4 If this pressure is not sufficient to seal the neck of the bag, the level of the heavy fluid in the bag can be raised by the pressure from outside An increased pressure, $h_1\ \varrho_h\ g$ at A is necessary to press the heavy liquid up to B, and may be produced from outside by application of force on the elastic wall of the container The increased pressure is propagated to all parts of the liquid and further compresses the bag If the liquid can be pressed up to B the compression will be $= h_1\ \varrho_h\ g$ larger than at A since $\varrho_h > \varrho_w$ Consequently the degree of narrowing of the neck of the bag varies with the difference in density between the two liquids

3 *Light fluid (oil) in bag* On increasing the pressure in the container, the level of the oil in the bag was readily raised (Fig 5)

It is thus evident that if a flexible bag with its mouth exposed to the atmosphere is partly filled with a heavy liquid and partly immersed in a closed container filled with a lighter liquid, the heavy fluid will fill the lower part of

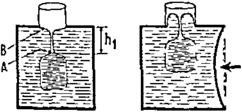


Fig 4 (compare fig 3) Heavy fluid (density ρ_h) in bag *Left* Surface of container exposed to atmosphere The heavy fluid fills lower part of bag *Right* Increased pressure inside the cavity The heavy fluid does not rise but the water is forced through the opening at the top of the cavity and the bag with the heavy liquid is lifted Density of water $= \rho_w$ (h = height)

the bag and that part of the bag above the level of the heavy fluid will be compressed by the surrounding liquid An increase in the pressure inside the container will compress the neck of the bag and may thereby prevent the liquid from being squeezed up through the bag The degree of narrowing of the neck of the bag will vary with the difference in density between the liquids If the fluid in the bag is as heavy as, or lighter than the liquid in the container no such narrowing of the neck of the bag will occur

Discussion

The existence of an abdominal segment of the oesophagus has been demonstrated by many investigators When barium flows into the stomach this segment is however roentgenologically indistinguishable from the oesophagus above the hiatus (CREAMER, HARRISON and PIERCE 1959) If the pressure in the abdominal cavity sufficiently exceeds that in the thoracic cavity during a roentgen examination in the erect position the flow of barium will be stopped at the level of the hiatus There will then be an 'empty segment or a sealed off segment between the hiatal level and the stomach Various attempts have been made to explain the underlying mechanism of this phenomenon on physiologic and anatomical grounds (JOHNSTONE 1955, BOTHA 1958 CREAMER HARRISON & PIERCE 1959 ZAINO, POPPEL, JACOBSSON, LEPOW & OSTURK 1960, WOLF 1960)

The model experiments described would appear to indicate however that the closure mechanism of the oesophagus as seen roentgenographically during swallowing may be explained largely in terms of physics

The presence of an empty segment during swallowing of heavy contrast media does not mean that there will be an empty segment if the difference in pressure between the abdominal and thoracic cavities is increased during the swallowing of food or water instead of barium The intraluminal pressure and pH recordings suggest that the segment is often not closed (SANDMARK to be published) During the swallowing of water ordinary food, or roentgen contrast media fluid is forced into the oesophagus and the stomach by pressure produced by buccopharyngeal and oesophageal muscle contractions as well as by gravity (KOCH INGELSTEDT & SANDMARK 1960) If the intraperitoneal

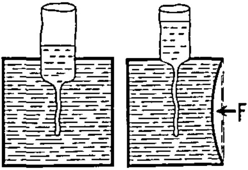


Fig 5 (compare fig 3) Light fluid (density ϱ_1) in bag *Left* Surface of container exposed to atmosphere The light fluid fills upper part of bag *Right* Increased pressure inside the cavity The bag is compressed and the lighter fluid in the bag rises

pressure sufficiently exceeds the intrapleural pressure, such as during deep inspiration, the intragastric pressure will exceed the intra oesophageal pressure and no more oesophageal contents will enter the stomach The gastric contents may then be forced up into the oesophagus if their density is the same or less than that of the surrounding tissue On the other hand, a liquid heavier than the surrounding tissue may press aside the gastric wall and reach the lowest point in the stomach There will then be an empty segment that will be compressed by the surrounding tis ue The degree of 'emptiness depends on the amount of gas on the viscosity and density of the liquid and on the adhesion between the latter and the gastric mucosa As a rule the compressed segment probably *includes not only the abdominal part of the oesophagus but also part of the* stomach This may also explain why the high pressure zone normally present at the gastro oesophageal junction is difficult to demonstrate during a barium meal examination

Pathologic conditions The pressure difference between the abdominal and thoracic cavities may under normal circumstances increase considerably, without any reflux of gastric contents entering the oesophagus There must consequently be an effective closing mechanism at the gastro oesophageal junction

The gastric contents generally enter the hernia easily in cases of sliding hernia even when the pressure difference between the abdominal and thoracic *cavities is moderately increased* (SANDMARK, *to be published*) If in these cases the pressure difference is increased still more, the closing mechanism at the gastro oesophageal junction may be forced open with reflux into the oesophagus Contrast medium administered by mouth will fill the lower part of the stomach and the gas free remainder of the stomach in the abdominal cavity may be compressed by the surrounding tissues With an increased pressure difference between the abdominal and thoracic cavities this compression may entirely prevent the contrast medium from coming up into the herniated portion

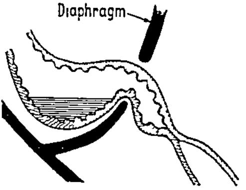


Fig 6 Case of sliding hernia examined with pelvis raised The lower part of the stomach is filled with a heavy contrast medium.

of the stomach or into the oesophagus Other abdominal viscera, lighter than the loaded stomach, may however be forced up towards the diaphragmatic hiatus and perhaps prevent herniation A conventional barium meal may consequently produce an effective closing mechanism although it may be absent after the ingestion of ordinary food

If the stomach is partly filled with contrast medium this effect may occur even with the pelvis raised (Fig 6) It should, however usually be easier to produce a reflux in this position owing to the weight of the contrast medium column which is then brought to act upon the closing mechanism

The use of heavy contrast medium in the investigation of clinical reflux and hiatus hernia may thus produce misleading results particularly if the examination is performed with the subject erect A contrast medium with a physical density similar to that of water would be more physiologic and perhaps facilitate the examination A new type of contrast medium consisting of barium sulphate powder and whipped cream (physical density ≈ 1 g/cm³) has been devised and preliminary trials have proved promising Detailed results obtained with this medium and with further technical modifications will be the subject of another paper

SUMMARY

Model experiments revealed the disadvantages of heavy contrast media in the demonstration of hiatus hernia and gastro-oesophageal reflux Preliminary results obtained with a lighter contrast medium have proved promising

ZUSAMMENFASSUNG

Experimente zeigten die Unzuganglichkeit von schweren Kontrastmitteln zur Darstellung der Hiatusbruche und des oesophagealen Refluxes Vorlaufige Experimente mit leichteren Kontrastmitteln versprechen besseren Erfolg

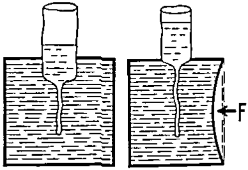


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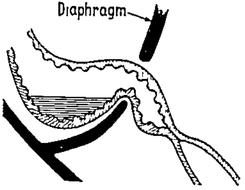


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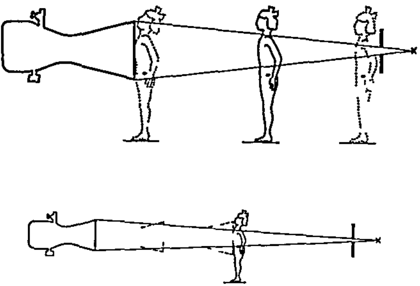


Fig 1 The principles of the enlargement technique It is more practical to move the patient from the screen towards the tube (upper row) than to move the camera (lower row)

resolution of the system This type of test plate by no means corresponds to the radiophotographic reproduction when depicting living structures but gives a good idea of the basic resolution capacity of the system Similar devices are currently being used for routine controls of the resolution and for focusing purposes in radiophotography as well as in image intensification and roentgen television A 0 3 mm focus tube energized by a 3 phase apparatus and run at 100 kV and 18 mA was employed The test plate was placed in turn at distances of zero cm, 25 cm 50 cm and 85 cm from the screen The focus screen distance was 105 cm the distance of 85 cm of the test plate from the screen was the maximum available and was limited by the construction of the tube and the cone

The results are presented in Fig 2 and the number of lines read from the original films are summarized in Table I

Experiments were carried out with and without a grid The lines of the test plate in the second instance were placed parallel to, perpendicular to, and in various directions oblique to the lines of the grid No noticeable differences could be detected between the resolution in the various positions The test plate in the different enlargements shown in Fig 1 was exposed without a grid

It was found in this phantom study that within the available distances between zero and 85 cm the resolution appeared to be increasing throughout It is generally held that a geometric enlargement of up to 2 × linear and

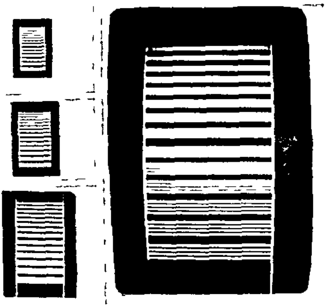


Fig 2 Examination of the resolution of the radiophotographic system at various distances between test plate and screen at zero cm (top left) at 25 cm (middle left) at 50 cm (bottom left) and at 85 cm (right view) At 50 cm distance the resolution is at the 2 × level

correspondingly to an area of 4 ×, is useful and usable in standard radiography The geometric unsharpness over 2 × becomes essentially greater than the unsharpness due to screens and graininess of the film

The present study appears to indicate that the geometric unsharpness as well as other factors influencing the resolution are different in radiophotography as compared with standard radiography Again the graininess of the emulsion used, Gevaert G Scopic is of course far less than that of the ordinary radiographic emulsions Because the size of the children to be examined practically never calls for an enlargement of more than 2 × this initial observation was not further developed

Table 1

Resolution in enlargement measured by using a test plate containing 14 groups of lines with 4 lines in each group

	Distances between screen—test plate			
	Zero cm	25 cm	50 cm	85 cm
Groups read	4	6	9	12
Lines read	16	24	36	48

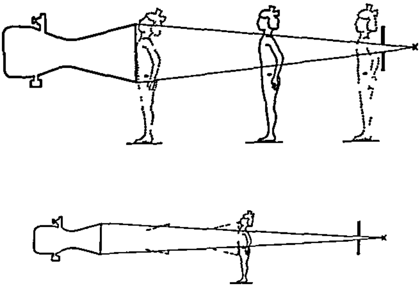


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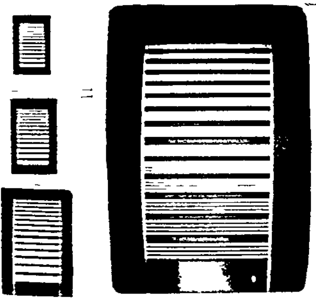


Fig 2 Examination of the resolution [illegible] at distances between test plate and screen [illegible] zero cm (top left) [illegible] cm (middle left) [illegible] cm [illegible] and at 85 cm (right view) [illegible] cm distance [illegible]

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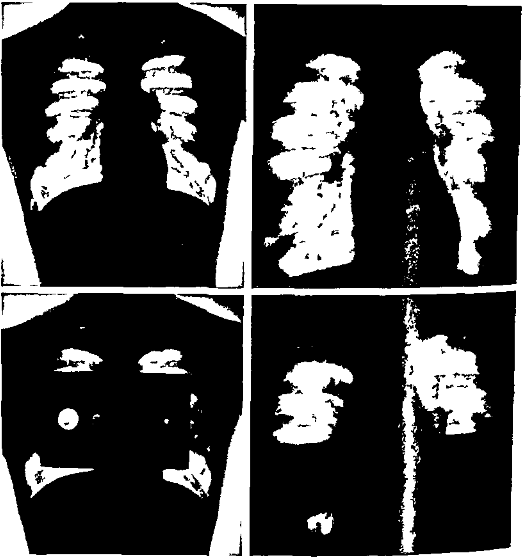


Fig 3 Examination of the scatter with grid removed There is no discernible evidence of scatter in either the normal films (upper row) or behind a protective plate (lower row) The two views to the left were exposed at zero distance from the screen the two views to the right at a distance of 50 cm from the screen

2 *The problem of scattered radiation and use of grid* It has been established that in standard radiography an air space of some 15 to 20 cm may be enough to eliminate the necessity of a grid to decrease scattered radiation The effect of scattered radiation is of course also a disturbing factor in radiophotography On the other hand, the presence of an air space in geometric enlargement and the possibility of removing the grid, is important from the point of view of

Table 2

Gonad doses in mr measured at various distances from the screen and in postero-anterior and lateral positions

Age groups	Sex	Distances between patient and screen					
		Zero cm		25 cm		50 cm	
		p a	lateral	p a	lateral	p a	lateral
12—14	1♂	1 5	1 3	1 3	1	0 8	1
	2♀	2 5	1 8	2	1 5	1	1 3
9—11	4♂	2	1 7	2	1	1 4	1 6
	6♀	3 4	1 8	1 2	1 5	1 2	2 5
6—8	3♂	3 2	2 1	2 5	1 7	1 2	2 5
	1♀	8	7 2	5	4 3	4 1	6

the tube load The load on the 0 3 mm focal spot approaches the upper limit and every means should be sought to decrease it Furthermore, the less the exposure the less the radiation risk to the patient, a factor that in recent times has been widely discussed in connection with radiophotography

The effect of the secondary radiation was examined by the following procedure A series of holes of decreasing diameter were drilled in a lead plate 10 × 20 cm in size, which was placed in front of the patient a ten year old girl (Fig 3) Films were obtained at zero cm 25 cm and 50 cm from the screen No effect of the scattered radiation could on direct visual inspection be detected behind the plate in the films exposed at these distances The factor which could have contributed to this result may have been the comparatively small size of the patient Further exposures in 13 and 14 year old children produced slightly disturbing effects due to scatter Children of this age approach the size of an adult and only a moderate enlargement can be obtained The practical conclusion of this experiment was that in mass chest examinations of schoolchildren the size of the subjects in the group to be examined should be taken into account Provided that the children are 10 years of age or under a grid should not be used but it should be included if the size of the children to be examined approaches that of adults

3 *Exposure factors* The patients were divided into three age groups of 6 to 8 9 to 11 and 12 to 14 years for the purpose of selecting the exposure factors as well as for measuring the radiation doses It was established in a series of trials that for the two groups of smaller children from 6 to 8 years and from 9 to 11 years, exposure factors of 100 kV and 20 mAs for the postero-anterior projection and 25 mAs for the lateral projection could be employed as a standard, 100 kV and 25 mAs for the postero anterior projection, and 32

mAs for the lateral, were necessary for the group of older children As the equipment in question did not allow for higher tube tension, the somewhat higher kilovoltage recommended in various quarters of up to 120 kV could not be investigated, this, however, refers to examinations in adults It is questionable whether any essential gain may be obtained by using a higher kilovoltage in paediatric radiophotography

4 *Radiation doses and radiation protection* An important question is whether the technique influences the radiation dose in an essential way The gonad dose as well as the volume dose have to be considered

As to the *gonad dose,* the following method was adopted in order to minimize radiation risks for the patients, and at the same time to guarantee constant measurements

A protected Sievers Walstam double ionization chamber was placed in the rectum of the girl patients Both the sagittal and the frontal projections were exposed twice, with the patients at distances of 0 cm, 25 cm and 50 cm from the screen The chamber was placed near the scrotum of the boys, and double exposures were made The chambers were read after every positioning and the reading was divided by the number of exposures The purpose of this arrangement was to level out slight variations due to the sizes of patients within an age group, and due to the technique itself, and thus to save the children from unnecessary repeat examinations

The results of the gonad dose measurements are summarized in Table 2 It is apparent that the doses show no increase as the patient is moved from the screen towards the focus but there is instead a slight tendency towards a decrease This result might be explained by the fact that the distance of the gonads from the direct radiation beam increases, while the distance from the focus decreases (see Fig 1) Again, the smaller the patient, the more the gonads are exposed, as may be seen by comparing the results in the various age groups The enlargement technique itself would consequently appear to constitute no additional radiation hazard as regards the gonad dose

With respect to the *volume dose* it was considered appropriate to carry out an investigation because the irradiated volumes may vary considerably with the geometric conditions An EIL portable ionization chamber and electrometer were available for this part of the study

A 7-year-old boy was placed at distances of 35 50 and 75 cm from the tube The ionization chamber was located in the centre of the beam in a sagittal projection The exposures, as in the gonad dose measurements, were made twice to control any unforeseen variations in the results The volume dose was calculated according to JOHNS (1961) as follows $D_v = k \times D \times A \; d_{50} \times a$

The result is presented in Table 3 It is evident that no untoward *increase* in the volume dose occurs as a result of the positioning of the subject at a

Table 3

Volume doses at various focal spot distances according to measurements and according to calculated values for restricted beam

Focal spot distance in cm	According to measurements: Surface dose mr	Field size (Input) cm²	d_{10x}	$1+\frac{2\ 88\times d_{10x}}{\text{focal spot distance}}$	Volume dose mr×cm²	Calculated volume dose for restricted beam
35	2 800	20×20	3 1	1 25	6 200	6 200
50	1 700	25×27 5	3 4	1 20	6 850	4 000
75	680	25×40	4 4	1 17	5 050	2 000

certain distance from the screen For the purpose of comparison a calculation was made of the volume dose presuming that the form of the beam would be changed continuously and kept strictly limited to the size of the chest It may be seen from Table 3 that the volume dose decreases with increasing distance

A strict control of the size of the radiation beam is indicated if the enlargement technique is not employed The radiation protection and in particular the gonad protection of adult subjects in radiophotography has been adequately emphasized in recent literature On the other hand serial examinations of schoolchildren with an unconfined beam may still be encountered There is of course every reason to stress the necessity in radiophotography of limiting the beam properly whatever technique is used

Discussion and Conclusions

The present investigation shows that it is quite feasible to use geometric enlargement in radiophotographic mass surveys of children of school age The main purpose is fully to utilize the size of the screen photographed and to increase resolution at least up to twice the linear An adaptation of the equipment in such a way that easy removal of the grid is possible appears to be desirable This refers particularly to the groups of children under the age of 10 years For children in the age group 12 to 14 years the use of a grid for elimination of secondary radiation appears to be necessary As the small focus of 0 3 mm carries a considerable load removal of the grid should be practised whenever possible

Some change in the projection of the anatomic entities within the chest has to be taken into account in an enlargement utilizing a fixed tube screen distance and varying positioning of the subject This geometric fact may not be considered a serious handicap Theoretically it should be possible to avoid by keeping the patient in position and by moving the camera to a suitable dis-

tance, an enlargement for instance of 2 × would thus require the camera to lie at a distance of about 200 cm (Fig 1) This solution hardly appears practicable, or may be rather complicated from the constructional point of view and because of the small focus employed A simple additional support to hold the child immobile during the examination is desirable when a fixed tube screen distance is used and the enlargement is obtained by moving the patient towards the tube

Radiation risks to the population caused by mass radiography has recently been much discussed, and it is therefore of some importance to establish that the enlargement technique does not entail any serious additional risk It was found that the gonad dose decreased slightly in the course of the investigation when the patient was moved towards the tube, the volume dose showed no significant increase Strict attention should be paid to the correct use of the diaphragm especially when no enlargement is being made

Acknowledgements

This study was begun during the author s tenure of a James Picker Foundation Research Fellowship at Thoraxklinikerna Karolinska Sjukhuset Wenner Gren Research Laboratory Norrtulls Sjukhus provided the test plate for the phantom study Elema Schonander AB were responsible for the technical facilities Financial support was later received from the Finnish Society Against Tuberculosis All this help is gratefully acknowledged

SUMMARY

A geometric enlargement technique may be recommended in mass radiophotographic examinations of schoolchildren A 0 3 mm focus tube and a simple support to immobilize the patient at the appropriate distance are the only special requirements

ZUSAMMENFASSUNG

Eine Vergrosserungstechnik wird fur die Reihenuntersuchung von Schulkindern mittels der Schirmbildmethode angeregt Man benotigt nur eine 0 3 mm Feinfokusröhre und einen einfachen Stand der Kinder festhalt

RÉSUME

On peut recommander une technique d agrandissement geométrique pour l examen radiophotographique systématique des écoliers Elle nécessite seulement un tube à foyer de 0 3 mm et un support simple pour immobiliser le sujet à la distance convenable

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FROM THE ROENTGENDIAGNOSTIC DEPARTMENT (DIRECTOR: PROF. OLLE OLSSON), UNIVERSITY HOSPITAL OF LUND, SWEDEN

RENAL FIBROLIPOMATOSIS

by

OLLE OLSSON and PER OLOF WEILAND

The sinus of the kidney is an important but roentgenologically neglected recess in the renal parenchyma which harbours the pelvis as well as the arteries, veins and lymphatics. The packing material for these somewhat fragile structures consists of fat, which makes the sinus easily accessible for roentgen examination. Apparently only a few papers have dealt with the normal and abnormal roentgen appearances of the sinus, the most detailed being that of WINDHOLZ (1951).

The anatomy of the sinus is well demonstrated in the nephrographic phase at urography, especially if stasis is present, but also in conventional films especially supplemented by tomography. An accumulation of fat in the hilum and sinus extending toward the lateral periphery as thin, somewhat irregular streaks is evident in conventional films, particularly in obese subjects. The sinus is more completely demonstrated by tomography, however, and if the renal pelvis retains some contrast material, fat is well shown around it as well as along the major and minor calyces. A detailed investigation of the normal roentgen appearances of the sinus as a background to the diagnosis of fibrolipomatosis by suitable methods is under preparation by WEILAND.

The sinus is diagnostically important in central tumours and for clarifying the shape and spread of backflow. We wish in this preliminary report to stress the additional importance of the sinus in the diagnosis of the entity renal fibrolipomatosis (or replacement lipomatosis and fatty replacement) (OLLE

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a b

Fig 4 Clinical diagnosis Chronic pyelonephritis a) Tomography Small kidney with very wide sinus (only cranial half in cut) b) Pyelography Elongated calyces impression from sinus side of cranial group of calyces

kidney may have a more or less widened sinus, again, a small kidney may have a very wide sinus (Figs 2, 4, 5, 6, 7, and 9) The changes may be bilateral Tomography may show the different parts of the kidney pelvis surrounded by an increased amount of fat A low kilovoltage and the superimposition of films will enhance contrast and assist in the demonstration of a widened sinus

Characteristic narrowing and lengthening of the branches of the kidney pelvis may be demonstrated at urography The distance between the branches may also be increased The calyces usually show lateral displacement and are often slightly impressed from the sinus side This slight displacement and deformation of the calyceal system is most marked in the early phases of urography when there is only slight calyceal filling (Figs 2 3, 4, 6, 7, and 8)

The intra arterial branches of the renal artery are narrower than normal and the distance between them is increased in cases of fibrolipomatosis studied by renal angiography (Figs 5, 6, 7 and 8) The vessels are sometimes arched and stretched and an increased distance between the ventral and the dorsal artery is often evident This combination of atrophy and displacement is also characteristic of hydronephrosis with atrophy of the parenchyma The basic

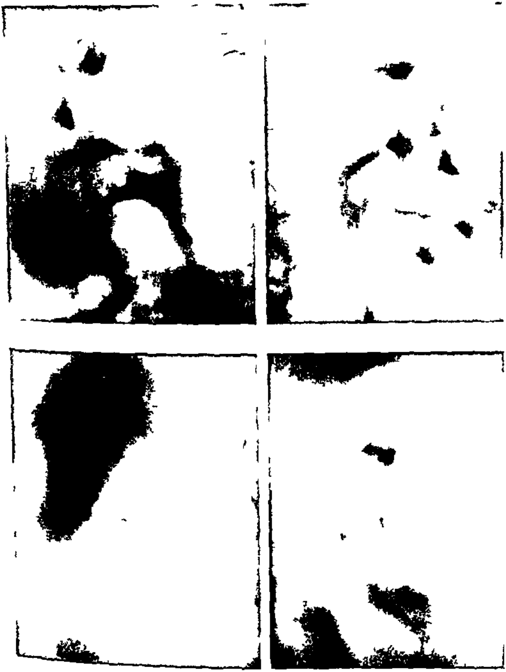


Fig 5 Clinical diagnosis Chronic pyelonephritis *Upper row* Urography Right kidney elongated narrow branches and calyces Left kidney small sinus widened *Lower row* Tomography Right kidney after release of ureteric compression is of normal size sinus widened Left kidney with fat filled scar formation below medio-lateral part continuous with fat in sinus



Fig 6 Same case as in fig 5 Renal angiography of right side Slight arterial atrophy and somewhat increased distance between branches

mechanism for the appearances is the same in the two conditions In fibrolipomatosis it is fat and in hydronephrosis the distended kidney pelvis containing fluid that fills out the widened sinus The widened sinus is well shown in the nephrographic phase of angiography The examination method introduced by EVANS DUBILIER & MONTEITH (1954) and called nephrotomography also demonstrates the widened sinus and will afford an indication of pyelonephritis (BOLIN 1961)

The diagnostic importance of fibrolipomatosis is stressed for two reasons

1 The amount of renal parenchyma is usually estimated from the size of the kidney as measured around its contours This method will fail to demonstrate internal atrophy A kidney of normal size with marked central fibrolipomatosis measured planimetrically will thus produce an erroneous impression of the amount of parenchyma An apparently normal sized or only slightly reduced kidney may in fact exhibit marked internal atrophy The limits of normal variations must be exceeded if the diagnosis of a decrease in size of the kidney is to be made A small kidney falling within the limits of normal variation may be classed as pathologic if a widening of the sinus is evident



Fig 7 Clin cal diagnosis Chron c pyelonephritis a) Urography Elongated branches and calyces impress on of calyces from the s nus side b) Angiography arterial phase Slight atrophy of intrarenal branches ith increased distance between ventral and dorsal b anch c) Nephrogr phic phase Very w de s nus d) Tomography somewhat later Filling of calyces hich are d placed towards the p r phery of the kidney and surrounded by a la ge amount of fat



a b c

Fig 8 Clinical diagnosis Carcinoma of pancreas retroperitoneal metastases with occlusion of ureter a) Urography Elongated branches and calyces impression from the sinus side in the cranial group of calyces Fat in sinus causes displacement of middle and caudal branches b) Renal angiography arterial phase Slight atrophy of arteries increased distance between ventral and dorsal artery c) Nephrographic phase Very irregular widened sinus



a b

Fig 9 Clinical diagnosis Nephrolithiasis + chron pyelonephritis very small kidney with markedly widened sinus a) Tomography Fat pad in caudal part of sinus b) Pyelography Small pel is with elongated branches Caudal branch and calyces displacement produced by fat pad in fibrolipomatos

2 The accumulation of fat may sometimes be so irregular and proliferative and the displacement so marked, as at urography or pyelography to suggest a tumour (Figs 8 and 9) Such cases have been subjected to operation (FRUMKIN 1947, SIMRIL & ROSE 1950) The appearances may also sometimes resemble those seen in a polycystic kidney Angiography will indicate the true nature of the condition although, if this examination cannot be performed, some help may be obtained from tomography

Conclusions

Fibrolipomatosis, contrary to the general belief, is a common condition and an important sign of pyelonephritis It may produce an error in the estimation of the amount of renal parenchyma

Circumscribed fibrolipomatosis may at urography have the appearances of a tumour The diagnosis may then be accurately established by the more definitive procedure of body section roentgenography or by renal angiography

SUMMARY

A preliminary report on renal fibrolipomatosis is presented The condition is not uncommon is often bilateral and exhibits fairly characteristic roentgen appearances

ZUSAMMENFASSUNG

Die Arbeit ist ein Vorbericht uber renale Fibrolipomatose Das Krankheitsbild ist keineswegs ungewohnlich oft beiderseitig und zeigt ziemlich typische Rontgenbilder

RÉSUMÉ

Les auteurs présentent un travail préliminaire sur la fibrolipomatose rénale Cette affection n est pas exceptionnelle est souvent bilatérale et a des signes radiologiques assez caracteristiques

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DEFORMATION OF THE RECTO SIGMOID JUNCTION IN PERITONEAL CARCINOMATOSIS

by

GEORG THEANDER LENNART WEHLIN and PER LANGELAND

The recto sigmoid junction is sometimes deformed by local backward protrusion of the anterior wall of the bowel The protrusion appears as a blunt transversal ridge which slightly reduces the lumen and exaggerates the normal bend of the bowel at this level The ridge is about 2 to 4 cm in breadth its mucosal surface being smoothly rounded or somewhat wrinkled by small folds running transversely to the bowel This deformity referred to in this paper as the junction deformity, is roentgenographically recognized by its characteristic appearance in the lateral view of the bowel and it receives diagnostic importance from its common occurrence in pelvic endometriosis (THEANDER & WEHLIN 1961) A few cases are however, on record in which it was found to occur in the absence of endometriosis In one of these the deformity developed after treatment for an ovarian carcinoma and in another it was seen in association with pelvic adhesions caused by terminal ileitis (THEANDER & WEHLIN) In a further case reported by HULTBORN MORALES & ROMANUS (1955) a true junction deformity was apparently caused by pelvic metastases from a pancreatic carcinoma

Observations made during and after surgery in some cases of the junction deformity suggest contraction of fibrous tissue at the recto-sigmoid junction

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Fig 1 Case 1 Junction deformity in a man aged 54 with carcinomatosis



Fig 2 Case 2 Junction deformity in a woman aged 58 with carcinomatosis

as the causal factor (THEANDER & WEHLIN) If this be so, the deformity would seem likely to occur in peritoneal carcinomatosis, since a cul de sac, such as the recto genital pouch is a site of predilection of the carcinomatous implants disseminated over the peritoneum in this condition (SCHENKEN & BURNS 1957) and since more or less marked fibrosis is known to be a constant feature of the resultant serosal lesions A systematic study of the recto sigmoid junction in peritoneal carcinomatosis was therefore thought desirable

Material and method The investigation was based on 50 cases of peritoneal carcinomatosis in which the bowel had been roentgenographically examined in our department before any treatment was given The films obtained were studied for any deformity of the rectum or sigmoid colon and the relevant clinical and histologic data were extracted from available records The primary tumour was an ovarian carcinoma in 35 cases, a uterine carcinoma in 6 cases, and a carcinoma of the bile ducts in 1 case, in the remaining 8 cases, the site of the primary tumour was unknown A characteristic junction deformity was present in 5 of the cases studied these five cases are presented below

Case reports

Case 1 A man aged 54 with a short history of vague abdominal pain constipation slight jaundice and increasing girth After withdrawal of 4 5 liters of ascitic fluid tumour masses were palpated in the abdomen and the liver was felt to be abnormally large Roentgen examination of the bowel revealed the presence of a junction deformity (Fig 1)



Fig 3 Case 3 Junction deformity in a woman aged 69 with carcinomatosis



Fig 4 Case 4 Junction deformity in a woman aged 56 with carcinomatosis

Death occurred two months later Autopsy disclosed a primary biliary duct carcinoma encroaching upon the stomach and secondary deposits in abdominal and thoracic lymph nodes in the liver and in the abdominal and pelvic serosa The gross appearances of the serosal lesions were those of disseminated carcinomatous masses with a generalized peritoneal fibrosis causing displacement and fixation of the intestinal loops by firmly contracted adhesions Histology revealed a mainly well differentiated adenocarcinoma in a fibrous stroma Such abnormal tissue covered but did not invade the large bowel including the sigmoid colon and rectum

Case 2 A woman aged 58 with a history of progressive fatigue loss of eight and increasing girth Clinical and roentgenographic examinations revealed the presence of ascites bilateral pleural effusion and a junction deformity (Fig 2) An extensive peritoneal carcinomatosis was found on laparotomy performed three weeks later and death occurred after another five months No radiotherapy was given At operation and on autopsy the serosal surface of the abdominal and pelvic viscera was seen to be covered by thick carcinomatous masses There was marked fibrosis with bridges of contracted fibrous tissue between the intestinal loops but no malignant invasion of the bowel The primary tumour was an ovarian carcinoma No endometriosis was present

Case 3 A woman aged 69 with a short history of dyspnoea and increasing girth A soft tissue tumour in the lesser pelvis together with ascites were observed on clinical examination and carcinoma cells were demonstrated in the ascitic fluid Roentgenography revealed the presence of bilateral pleural effusion and a junction deformity (Fig 3 It was assumed that the primary tumour was an ovarian carcinoma and radiotherapy was given This included two intra uterine radium applications with a 3 weeks interval (total dose 3 360 mgh) simul



Fig 5 Case 5 Junction deformity in a woman aged 72 with carcinomatosis

taneous external conventional roentgen therapy (HVL 1 mm Cu FSD 60 cm) over four pelvic fields (total skin dose 2 400 r per field spread over four weeks) and additional roentgen treatment over two upper abdominal fields after a 5 weeks interval (total skin dose 1 600 r per field spread over 9 days)

Further treatment was prevented by the rapidly deteriorating general condition of the patient and death occurred four months after the roentgen examination The autopsy disclosed large masses of papillary adenocarcinoma on the surfaces of the pleura and peritoneum including the ovaries and secondary carcinoma of the liver and several lymph nodes The primary tumour was presumably situated in the right ovary though it could not be identified with certainty There was extensive peritoneal fibrosis with firm contracted adhesions between the abdominal wall and some intestinal loops and fibrous obliteration of the recto-uterine fossa On histologic examination of specimens taken from the rectum and sigmoid colon *carcinomatous lesions were observed in the adherent fibrous tissue* although not in the actual wall of the bowel No endometriosis was present

Case 4 A woman aged 56 with a short history of constipation low abdominal pain and increasing girth Ascites and a walnut sized retro uterine tumour were found on clinical examination and adenocarcinoma cells were demonstrated in the ascitic fluid Roentgenography revealed the presence of a junction deformity (Fig 4)

Radiotherapy consisting of two intrauterine radium applications with a 3 weeks interval (total dose 3 360 mgh) one vaginal radium application (dose 1 600 mgh) and simultaneous external conventional roentgen therapy (HVL 1 mm Cu FSD 60 cm) over four pelvic fields (total skin dose 2 000 r per field in 4 weeks) was administered

On laparatomy two months after the roentgen examination extensive peritoneal carcinomatosis with marked fibrosis prevented close inspection of the pelvic organs The primary tumour was not identified with certainty but it was probably an ovarian carcinoma *Death occurred* about two months after the operation autopsy was refused

Case 5 A woman aged 72 was being intermittently observed for chronic polyarthritis and sarcoidosis of 20 and 10 years duration respectively During the autumn of 1961 some ill defined lumps of soft tissue were palpated in the abdomen and lesser pelvis and roentgen examination of the bowel revealed the presence of a junction deformity (Fig 5)

Laparotomy performed one month later disclosed a peritoneal carcinomatosis with moderate ascites and multiple tumour deposits of various size in the parietal and visceral serosa Close inspection of the pelvic organs was not possible because of extensive contracted adhesions and the primary tumour was not identified

The roentgenographic appearances of the rectum and sigmoid colon were normal in the remaining 45 cases studied except for gross displacement of the sigmoid colon in some cases with a large primary ovarian carcinoma The history and clinical findings were essentially similar to those in the cases reported above Ascites was usually present on admission The diagnosis of peritoneal carcinomatosis was histologically established on autopsy or biopsy and fibrosis was found to be a regular feature of the serosal lesions

Discussion

Any deformation of the bowel in peritoneal carcinomatosis might a priori seem likely to be due to the intramural growth of malignant tissue or to the pressure exerted by some neighbouring tumour or tumours This explanation was however apparently not valid for the junction deformity observed in 5 of the 50 cases studied since autopsy performed in 3 of these cases failed to demonstrate any intrusive tumour or malignant infiltration of the bowel at the recto sigmoid junction The absence of such local changes would seem to favour the conception that the junction deformity in peritoneal carcinomatosis is related to the serosal fibrosis regularly found in this condition

The occurrence of the junction deformity in peritoneal carcinomatosis as well as in benign conditions such as pelvic endometriosis, might seem to imply a serious limitation of the diagnostic value of the deformity It should be observed however, that the 10 per cent incidence of the deformity recorded in the former condition is comparatively low, since in pelvic endometriosis a junction deformity was roentgenographically demonstrated in as many as 6 out of 8 cases studied (THEANDER & WEHLIN) Clinical data may help to recognize the underlying condition in a given case of the deformity for example, in our 5 cases of junction deformity in peritoneal carcinomatosis ascites had in four of the cases been observed on admission

SUMMARY

A characteristic deformity of the recto-sigmoid junction (junction deformity) most often observed in pelvic endometriosis and apparently related to serosal fibrosis was roentgenographically demonstrated in 5 out of 50 cases of peritoneal carcinomatosis

ZUSAMMENFASSUNG

Eine charakteristische Deformität des Darmes im Grenzgebiet zwischen Rectum und Sigma, die meistens bei Beckenendometriose beobachtet und auf Serosafibrose zurückgeführt worden ist, liess sich röntgenologisch in 5 von 50 Fällen von Peritonealkarcinose nachweisen.

RÉSUMÉ

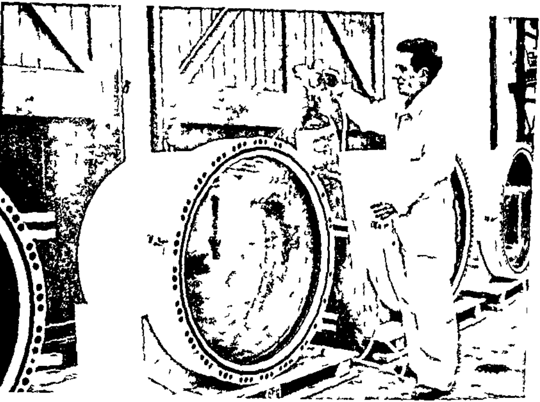
Une déformation caractéristique de la jonction recto-sigmoïdienne observée le plus souvent dans l'endométriose pelvienne et paraissant due à une fibrose péritonéale a été mise en évidence radiologiquement dans 5 cas sur 50 de carcinomatose péritonéale.

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FROM THE ROENTGENDIAGNOSTIC DEPARTMENT (DIRECTOR PROF OLLE OLSSON),
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RENAL ARTERY ANEURYSMS

by

ERIK BOIJSEN and ROLF KOHLER

Only some 200 cases of aneurysm of the renal artery have been described to date This does not however, imply that the condition is so rare as might at first be imagined since half the cases have been published during the last decade and some authors e g EDSMAN (1957) POUTASSE (1957) and MATHE (1959) have each reported 10 or more cases

Aneurysms are usually unilateral According to NESBIT & CRENSHAW (1956) only one case of bilateral aneurysms of the renal arteries had been described before the publication of their own case a few further cases of bilateral aneurysms have since been reported (MC LELLAND 1957 POUTASSE PLATT 1961) A strikingly high incidence, even in cases examined angiographically was reported by EDSMAN (5 cases of bilateral aneurysms out of 7 cases)

The aneurysm is usually located in the main renal artery or its primary branches but may also arise from supplementary arteries (SMITH & WALKING 1935 CHAMBERLIN & HOVENANIAN 1953)

Most aneurysms of the renal artery have been found in subjects between 50 and 70 years of age This age group also shows the highest incidence of degenerative vascular changes Renal aneurysms have however also been seen in younger age groups and even in children under a year old The condition is equally common in both sexes and in both kidneys

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Two main types of aneurysm are usually recognized aneurysma verum and aneurysma spurium A true aneurysm is defined as a localized dilatation of the renal artery retaining one or more of the original coats of the artery wall A false aneurysm is one whose walls are derived from tissues originating outside the artery and may be the result of rupture of a pre existing true aneurysm or a normal or diseased renal artery The term 'false aneurysm is probably mis leading since the condition is actually one of a hematoma with arterial com munication (POUTASSE) Thirty five of the 115 aneurysms in ABESHOUSE s (1951) compilation were of the false type The term 'aneurysm' in this communication is to be understood as aneurysma verum, which is the more important variety and which may be readily distinguished angiographically from other renal lesions

There is general agreement that the primary causal factor in renal aneurysms is a weakening of the arterial wall, particularly the elastic tissue of the media Congenital traumatic, inflammatory or degenerative lesions have been described as producing such weakening which because of the arterial pressure, results in the development of an aneurysm It is now widely accepted that most renal aneurysms are the result of the same type of degenerative process in the vessel wall as aneurysms in other organs An increased demand on the renal artery, e g solitary kidneys (EDSMAN 1957 HARROW & SLOANE 1959), renal carcinoma VON FIRCKS 1937 BEGNER 1955, GEORDAN 1958), and arteriovenous fistulae (BOIJSEN & KOHLER 1962), seem to be able to cause an aneurysmal widening of the vessels Stenosis of the renal artery, because of the jet effect, may cause poststenotic aneurysmal widening

The saccular type of renal aneurysm is the commonest one and communicates with the lumen of the artery by a narrow or wide opening The fusiform type is characterized by a more or less localized dilatation of the entire lumen of the artery Dissecting aneurysms of the renal artery are very rare (GILFILLAN SMART & BOSTICK 1956) and in a strictly pathologic sense are not true aneurysms The arteriovenous fistula is also usually included among renal aneurysms This type has however been described elsewhere (BOIJSEN & KOHLER) and will therefore not be discussed

Material The material consisted of 14 aneurysms found in 12 subjects (8 females and 4 males) aged between 43 to 72 years, one of these had bilateral aneurysms and one had two aneurysms on the same side

Findings

Conventional examination and urography All 12 cases were subjected to urography on one or more occasions Calcifications due to aneurysm in the region of the kidney were evident in 4 cases in 2 of these the entire wall excluding the neck of the aneurysm was calcified, in the third case the calcification was

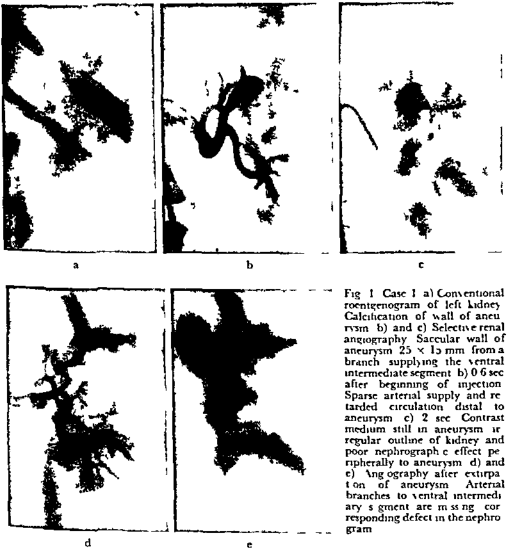


Fig 1 Case 1 a) Conventional roentgenogram of left kidney Calcification of wall of aneurysm b) and c) Selective renal angiography Saccular wall of aneurysm 25 × 15 mm from a branch supplying the ventral intermediate segment b) 0 6 sec after beginning of injection Sparse arterial supply and retarded circulation distal to aneurysm c) 2 sec Contrast medium still in aneurysm irregular outline of kidney and poor nephrographic effect peripherally to aneurysm d) and e) Angiography after extirpation of aneurysm Arterial branches to ventral intermediary segment are missing corresponding defect in the nephrogram

irregular and measured 13 × 5 mm while in the fourth case the mural calcification resembled a cast of a calyx (Fig 1a)

The aneurysm had caused no impression upon the renal pelvis in any of the 12 cases There was marked localized reduction of the parenchyma in 2 cases and in one (Fig 2a) of these no contrast medium was excreted

Angiography The indications for angiography in the 12 cases were tumor pyelonephritis calculus hydronephrosis and hypertension Eleven of the 12 cases were subjected to bilateral renal angiography The aneurysms were



a b

Fig 2 Case 2 a) Urography Reduced parenchyma in upper part of right kidney b) Aortic renal angiography Aneurysm of dorsal artery (→) 5 × 5 mm and markedly reduced branches (→) of this artery

diagnosed by aortic angiography in 7 cases and by selective renal angiography in 5 cases

The aneurysms were bilateral in one case, and were situated in the right renal artery or its branches in 7 cases and on the left side in 4 cases

Three aneurysms were found at angiography to be extrarenal, 7 were situated in the renal hilum and 4 in the region of the renal sinus The sites of the aneurysms were as follows 2 in the renal artery each 1 cm before its bifurcation 6 aneurysms were situated at the bifurcation of the renal artery into the dorsal and ventral artery (Figs 2 4, 6, and 7) and 3 at the origin of or peripheral to the ventral artery (Figs 1 and 3) The remaining 3 aneurysms were situated in the proximal part of the lower polar artery (Figs 5 and 7)

Nine aneurysms were of the saccular type and 5 of the fusiform type The former were usually somewhat oval but with a smooth outline Two of the fusiform aneurysms were spindle shaped and very irregular in outline The largest two measured 25 × 15 mm and 30 × 14 mm and the smallest two 3 × 2 mm and 7 × 5 mm respectively

The circulation in the aneurysm as it appeared at angiography was retarded in 3 of the saccular cases, contrast blood persisting in the aneurysm 1 to 2 seconds after it had disappeared from vessels at the same level (Fig 1), the circulation was only slightly retarded in one saccular aneurysm and 2 fusiform aneurysms



Fig 3 Case 3 Selective renal angiography Right kidney left oblique Renal artery tortuous and irregular saccular aneurysm 18 × 14 mm from bifurcation of ventral artery in upper medial renal hilum

The general circulation in the kidneys as demonstrated at angiography was not impaired by the aneurysms The local circulation peripheral to the aneurysm was however, markedly retarded in one of the 3 above mentioned saccular cases This case also showed sparse vascularity peripheral to the aneurysm and a weaker nephrographic effect in that area a corresponding reduction of the cortex was evident and the surface was irregular All the other cases in which the rate of flow of the blood to the aneurysm was only slightly retarded also had a somewhat slow local peripheral circulation The branches distal to the aneurysm had a markedly reduced caliber in 2 saccular aneurysms located at the origin or first part of the dorsal artery (Fig 2b) The passage of contrast medium through these small arteries was, however the same as in the other renal arteries The parenchyma was reduced and the dorsal artery and its branches were narrowed

Four of the cases displayed distinct signs of atheromatosis of the renal vessels as manifested by increased width tortuosity or irregularity of outline (Figs 3 and 7)

Results of operation Five of the cases were subjected to nephrectomy The aneurysm could not be resected in two of these cases (Cases 3 and 4) Operation was performed in one case mainly because of obstruction from a stone at the ureteropelvic junction in association with pyelonephritis and nephrectomy was carried out in one case (Case 6) for multiple cysts of the right kidney and perirenal bleeding caused by the aneurysm in the fifth case the main indication for operation was a malignant renal tumor

The aneurysm was resected in two cases (Cases 1 and 5), the procedure being followed by infarction involving the ventral intermediate segment and dorsal part of the lower pole, respectively. Postoperative angiography revealed that the aneurysm had disappeared and the vessels distal to its previous location were no longer apparent. There was no accumulation of contrast medium in the parenchyma supplied by these vessels during the nephrographic phase (Fig. 1, d and e, and Fig. 5b).

Case reports

Case 1. Female aged 46 with occasional pain in the left flank for four years but no urinary symptoms. BP 165/100.

Conventional roentgenography. A 2 mm calcification in the middle of the left kidney noted four years previously now measured 17 × 8 mm and had the shape of an upper calyx (Fig. 1a).

Urography disclosed that the calcification lay medially to the superior branch of the renal pelvis and not in a calyx.

Selective renal angiography was performed to evaluate the distribution of the vessels for partial nephrectomy. It was found that the calcification actually lay in the wall of an aneurysm measuring 25 × 15 mm. The aneurysm was situated in an arterial branch of the ventral intermediate segment immediately distal to its division and delayed the circulation in this area. The vessels were irregular, the outline of the kidney was uneven, and it was not possible in the nephrographic phase to distinguish the cortex from the medulla in the ventral intermediate segment (Fig. 1, b and c).

The renal artery was dissected free and the aneurysm was found to be situated at the site indicated by the angiogram; the calcification lay dorsally in the wall of the aneurysm. The aneurysm was removed and its afferent vessel ligated. A 2 cm infarct was produced. Macroscopically the aneurysm was pedunculated with a thickened and partly calcified wall except superiorly where it was thin; a small mural thrombus was present. The aneurysm appeared histologically to be due to a defect in the elastica of the vessel wall. The postoperative course was uncomplicated.

Further *selective angiography* (Fig. 1, d and e) demonstrated no vessels running to the ventral pars intermedia and in the nephrographic phase a defect was evident at the same site combined with shrinkage of this part of the kidney. The vessel supply to the rest of the kidney was normal.

Case 2 (Fig. 2). Female aged 67 with known hypertension (BP 200/100) and evidence of recurrent pyelonephritis with a raised temperature and pain in the right side for more than 20 years.

At *urography* a marked reduction of the renal parenchyma in the upper pole of the right kidney with irregularity of the surface and dilatation of the calyces in this region was noted.

Aortic renal angiography revealed a 5 × 5 mm aneurysm arising from the dorsal artery at its origin from the renal artery; the caliber of the dorsal artery and its branches was markedly reduced. No operation was performed owing to the poor general condition of the patient.

Case 3. Female aged 44 with evidence for several years of left pyelonephritis. BP normal.

Urography. Normal conditions on the left side. The right kidney contained a small thin faint calcification adjacent to the upper part of the renal hilum; the two inferior calyces were separated by an expanding process about 1 cm in diameter.

Bilateral selective renal angiography revealed atheromatous mural irregularities of the right renal artery and the ventral artery and an aneurysm 14 × 11 mm was evident at the bifurcation of the ventral artery (Fig. 3). The calcification seen at urography lay in the wall of the



a b

Fig 4 Case 4 Selective renal angiography right kidney a) Left oblique b) Frontal Aneurysm 15 × 13 mm at division of dorsal and ventral artery

aneurysm The arteries of the lower pole were separated by a small cyst The left renal artery was tortuous but otherwise normal It was not found possible to extirpate the aneurysm which as shown by angiography was sessile nephrectomy was performed Examination of the specimen showed that the aneurysm had a thin wall especially superiorly where the lamina elastica interna and media were replaced by fibrous tissue a small cyst was present in the lower pole of the kidney

Case 4 Female aged 67 with dull pain in the right flank and hematuria BP was elevated (190/110)

At *urography* a 15 × 20 mm filling defect was evident in the confluence of the kidney pelvis probably caused by a papilloma or a blood clot attached to the wall

Selective right renal angiography was performed and an aneurysm 15 × 13 mm was demonstrated at the bifurcation of the dorsal and ventral arteries in the renal hilum (Fig 4 The filling defect in the kidney pelvis was caused by a blood clot It was not possibl to extirpate the aneurysm which was situated at the bifurcation of the main renal art ry and inv lved all the branches except the two running to small segments in the upper and lo er pel s old hemorrhage in the vascular pedicle was evident Nephrectomy was performed

Case 5 Female aged 43 with cystitis and pyelonephritis BP n rmal

Urography and *right selective renal angiography* disclo ed numerous pyelonephritic changes in the right kidney There was reflux of a small amount of contrast medium to the left renal artery and signs suggesting an aneurysm were apparent

Left selective renal angiography disclosed a 12 × 8 mm aneurysm ar s ng from the lower polar branches of the dorsal artery (Fig 5a) This was extirpated and the vessel to the posterior part of the lower pole ligated with the production of a small infarct in this part of the kidney



a b

Fig 5 Case 5 Selective renal angiography left kidney a) Aneurysm 12 × 8 mm extending proximally from lower polar branch of dorsal artery b) Postoperative Lower branch of dorsal artery ligated

Pathologic examination of the aneurysm showed normal arterial cell elements basally in the aneurysm the upper part of which was covered by thin fibrous tissue without elastica small thrombi were evident in some regions Further left renal angiography demonstrated that the aneurysm and the lower polar branches of the dorsal artery had been extirpated with a corresponding defect in the nephrogram (Fig 5b)

Case 6 Male aged 50 with normal blood pressure

Urography performed during an acute attack of right abdominal pain revealed changes suggesting an expanding process in the lower part of the right kidney with medial displacement of the ureter

Aortic angiography one month later disclosed multiple cysts in the right kidney in addition there was evidence of a fusiform arterial aneurysm at the bifurcation of the ventral artery The left kidney was normal At operation a large hematoma enclosed by a fibrous capsule surrounded the lower and middle parts of the right kidney Nephrectomy was performed Examination of the specimen revealed no source of active bleeding but the wall of the aneurysm was very irregular and arteriosclerotic A previous rupture of the aneurysm was *considered* to be the cause of the old hematoma around the kidney The upper and middle parts of the kidney contained multiple cysts

Case 7 Male aged 60 was admitted for the investigation of periods of raised temperature and malaise but no other symptoms BP slightly elevated (165/85)



Fig 6 Case 7 Aortic renal angiography Bilateral aneurysm from main bifurcation of renal artery The right aneurysm measured 20 × 18 mm and was of the saccular type the left measured 19 × 15 mm. The branches of the superior mesenteric artery are obliterated

At *urography* a 13 × 5 mm calcification was demonstrated adjacent to an upper calyx of the left kidney the pelvis was normal in shape

Aortic renal angiography (Fig 6) The calcification in the left kidney was located in the wall of an aneurysm measuring 19 × 15 mm situated at the bifurcation of the dorsal and ventral arteries A further aneurysm 20 × 18 mm in size was present at about the same relative site on the opposite side The contrast medium passed slowly through the aneurysms on the two sides An incidental finding was marked atheromatosis of the secondary branches of the superior mesenteric artery several of which were occluded The situation of the aneurysms and the fact that they were bilateral precluded operation

Case 8 Male aged 51 with known hypertension (210/120) for 3 years

Urography No obvious abnormality

Aortic renal angiography demonstrated that the left renal artery was somewhat tortuous but otherwise not abnormal An aneurysm 5 × 10 mm in size was present in the lower polar artery just distal to its origin from the right renal artery Stenosis of the first part of the former artery was also evident

Selective right renal angiography (Fig 7) demonstrated that the aneurysm caused no obvious circulatory disturbances A second aneurysm measuring about 14 × 9 mm was also revealed at the bifurcation of the dorsal and ventral arteries this further aneurysm had been interpreted in the aortic angiogram as being an arterial tortuosity Surgical intervention is planned



Fig 7 Case 8 Selective right renal angiography Two aneurysms one at origin of lower polar artery with stenosis of the first part of this branch (→) the other at the bifurcation of the dorsal and ventral arteries (↠)

Discussion

True aneurysms are often asymptomatic but may cause pain and hematuria ABESHOUSE in his extensive survey found that pain occurred in about 50 % and hematuria in about 30 % of all cases It should however, be pointed out that about 30 % of the 115 cases of this author s material were false aneurysms and these are probably more apt to give symptoms than true aneurysms Abdominal and low back pain as well as hematuria occur in a number of urologic diseases It was not possible in the present material to estimate the degree to which the aneurysm caused pain or hematuria as most cases had other renal lesions

Opinions on the prognosis of untreated renal artery aneurysms and indications for surgical removal have differed but nowadays unanimity exists regarding active treatment ABESHOUSE stated The potential danger of spontaneous or traumatic rupture with its due consequence and fatal termination does not justify a conservative policy MATHE (1948), NESBIT & CRENSHAW (1956) and GARRITANO (1957) also insisted that immediate surgical intervention is the treatment of choice IPPOLITO & LE VEEN (1960) recommended operation of all aneurysms in young subjects and pregnant females Seven cases of aneurysm have been described in pregnant women, all of which were left sided and all of which ruptured (CHISHOLM 1926, ÖSTLING 1938 HACK 1953, BURTH et coll 1956) Non calcified aneurysms are apt to rupture

and should be removed. In two of our cases operation demonstrated that the aneurysm had ruptured and caused perirenal bleeding (Cases 4 and 6), none of these was calcified.

None of the many case reports in the literature mentions rupture of a calcified aneurysm. Thus, apart from pregnancy, calcified aneurysms do not indicate immediate surgery. Small calcified aneurysms may need surgical treatment only if they grow. Operation should be considered particularly if hypertension exists, if an aneurysm originally exceeds 20 to 30 mm in diameter (ALAZRAKI & BRUDO 1960).

Hypertension has been noted in about 15 % of cases of renal aneurysm (DAVIDSON & COE 1956, NESBIT & CRENSHAW 1956, MILLER & GARVAN 1957, POUTASSE 1957, MATHE 1959, DUBOST & CHEVRIER 1960); the blood pressure in many cases became normal after nephrectomy. Seven of the 12 cases of the present material had moderate hypertension, only three of them were operated upon but a complete follow up of the hypertension is not available.

The increasing number of renal angiographies now performed because of hypertension will certainly disclose an increasing number of renal artery aneurysms. These may be of two types. Fibro-muscular hyperplasia or true stenosis may cause a fusiform widening of the renal artery or one of its branches peripheral to the obstruction (so called jet aneurysm). A saccular aneurysm may also be related to hypertension; this aneurysm may cause a total or partial reduction of the blood flow through the kidney and thus be the origin of the hypertension, or it may be secondary to degenerative changes in the vessel wall.

Since aneurysms are regarded as rare and since the symptoms they produce may be vague, an aneurysm is usually an incidental finding at an examination performed for some other reason. In none of the 12 cases was the presence of an aneurysm indicated previous to the roentgen examination. The diagnosis in 2 of these cases was made at urography from characteristic calcifications in the wall of the aneurysm, while in the remaining 10 cases the aneurysms were revealed first at renal angiography. The preoperative diagnosis of a renal arterial aneurysm is thus usually made by a conventional examination or by renal angiography.

KEY & ÅKERLUND (1917) were the first to describe typical calcifications in the wall of the aneurysm. The calcifications have not always, however, a characteristic appearance. Thus 3 of the 4 cases of calcified aneurysm in our material had the annular calcification adjacent to the upper part of the renal hilum; in one of these the calcification was so thin and small that it was first recognized only after angiography had demonstrated an aneurysm. The calcification in the fourth case had a calyx shaped appearance and was located close to the upper calyx. The aneurysm found in this case was situated in the renal sinus and was therefore closely related to the calyx.

POUTASSE found 9 calcified aneurysms in his material of 12 cases which were verified by angiography. This is a remarkable high incidence when

compared with the compilation of ABESHOUSE (every fourth aneurysm calcified). The findings of EDSMAN (3 out of 12 aneurysms calcified) and of the present authors (4 out of 14 aneurysms calcified) are close to the results of ABESHOUSE.

Aneurysms sometimes cause impressions upon the renal pelvis. Cases have been described by MATHE (1948), for example, where deformation had been originally ascribed to a tumor, but at operation proved to be a hilum aneurysm. This also applies to PITKANEN's (1955) case, in which an aneurysm 7 cm in diameter, caused displacement of both the renal pelvis and ureter. A deformation of the upper medial part of the pelvis may however also be caused by tortuous renal arteries (WOLKE 1936, BOIJSEN 1957).

An aneurysm is also capable of causing a reduction of the vascularization of a part of the kidney, with secondary shrinkage of the parenchyma. It is possible at urography to observe an irregular renal surface and a reduced distance between the dilated calyces and the surface of the kidney. Some of the papillary necroses and so called dysplastic kidneys may thus take their origin from arterial aneurysms.

Renal angiography is the best method for diagnosing an aneurysm before operation, as well as for locating the origin of the process and its position. It is possible by aortic renal angiography to estimate the vascularization of both kidneys at the same time as well as to see the first parts of the renal arteries, i.e. a common site of stenosis in hypertension of renal origin. Selective renal angiography on the other hand, affords greater possibilites of detailed analysis of the renal arterial tree which is of great help in the planning and performance of surgical intervention for an aneurysm. Even if aortic angiography usually suffices to diagnose at least a large or medium sized aneurysm selective study of the diseased kidney is recommended in every case in which operation is contemplated. This is particularly important since it is now possible to reconstruct the arterial tree or to excise the aneurysm without sacrificing the entire kidney.

The state and function of the other kidney should be carefully considered in the evaluation of indications for operation. It should be stressed in this connection that when planning nephrectomy the opposite kidney should always be examined angiographically for aneurysm.

SUMMARY

Problems in the diagnosis of aneurysms of the renal artery are considered with special reference to a material of 12 cases. The value of renal angiography and particularly of selective angiography in the examination of these conditions is stressed.

ZUSAMMENFASSUNG

Probleme der Diagnose von Aneurysmen der renalen Arterie werden an Hand von 12 Fallen besprochen. Der Wert der renalen Angiographie und besonders der selektiven renalen Angiographie fur die Diagnose solcher Falle wird betont.

RÉSUMÉ

Se basant sur une série de 12 cas les auteurs étudient les problèmes que pose le diagnostic des anévrismes de l artère rénale Ils soulignent l intérêt de l angiographie rénale et en particulier de l angiographie sélective pour le diagnostic de cette affection

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RESPIRATORY KYMOGRAPHY IN POSTOPERATIVE PULMONARY COMPLICATIONS

by

SAM SCHMIDT

Postoperative pulmonary complications are especially common after abdominal operations the most frequent being atelectasis Impaired postoperative ventilation is regarded as one of the main causes of atelectasis Reflex guarding of the abdominal muscles and diaphragm during painful respiration after laparotomy and increased bronchial excretion caused by anaesthesia are probably the more important factors in impaired ventilation

A less common but more serious postoperative complication is pulmonary embolism Both atelectasis and embolism may be accompanied by secondary infection in the form of bronchopneumonia with or without pleural effusion

Kymographic examinations of the respiratory movements of the diaphragm and ribs (7th to 10th) in 21 cases of various postoperative pulmonary complications were performed with the object of investigating the respiratory mechanics No literature on kymography in such cases could be found

For details of the technique normal kymographic appearances and literature on respiratory kymography the reader is referred to the paper on respiratory kymography in acute pulmonary diseases published in Acta Radiologica Diagnosis Vol 1 (1963) 1032 and to previous articles (SCHMIDT 1960 and 1961)

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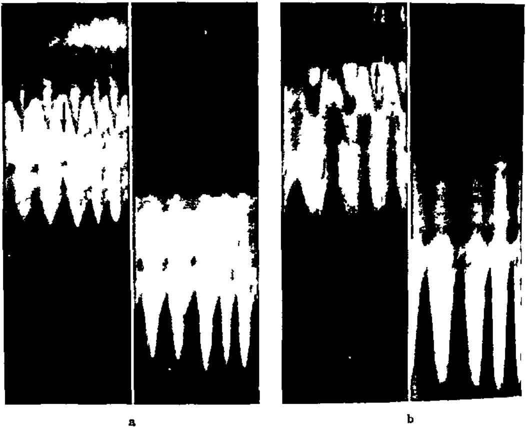
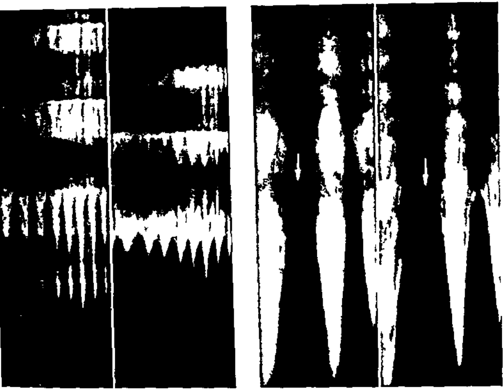


Fig 1 Right basal bronchopneumonia with atelectasis and small pleural effusion 5 days after percutaneous transhepatic cholangiography and choledocholithotomy Kymography in ordinary (a) and deep (b) respiration Normal diaphragmatic and costal waveform Markedly reduced diaphragmatic and costal amplitude (arrows) on the affected right side

Material Twenty one cases of postoperative pulmonary complications were examined by respiratory kymography, 18 of these had undergone abdominal operation, one thyroidectomy and one ablatio mammae

The following conditions were found

	Cases
Bronchopneumonia	9
Pulmonary embolism	5
Pleurisy	3
Atelectasis	3
Pneumonia	1
Total	21



a b

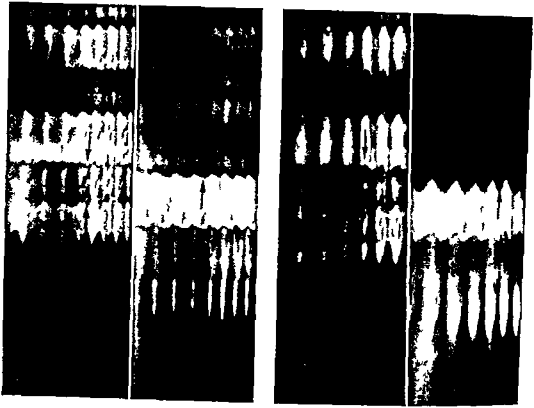
Fig 2 Same case as in fig 1 six months later freedom from symptoms Kymography in ordinary (a) and deep (b) respiration Normal kymographic appearances large diaphragmatic amplitude bilaterally in deep breathing (arrows)

In 18 cases the pulmonary process was unilateral in 9 of these the right lung was involved and in 9 cases the left lung The remaining 3 cases exhibited bilateral changes In 6 of the cases of bronchopneumonia there was evidence of atelectasis and this was probably the primary condition

The age of the patients varied from 24 to 76 years The length of the history calculated from the day of operation was 2 to 18 days the average being eight and a half days

Results

Diaphragmatic respiratory movements The form of the diaphragmatic movement waves was normal on both sides in 13 cases (Figs 1 and 3) step formed in 5 (Fig 5) and plateau shaped in 2 cases In one case of right sided broncho pneumonia the wave was plateau shaped on the affected side and normal on the left side (Fig 6)



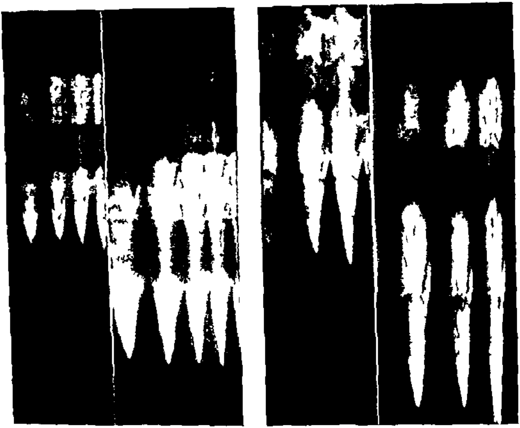
a b

Fig 3 Right pulmonary embolism with moderate pleural effusion 2 weeks after cholecystectomy Kymography in ordinary (a) and deep (b) respiration Normal waveform markedly reduced diaphragmatic amplitude mostly on the affected right side Slightly reduced costal amplitude bilaterally (arrows)

In 18 cases with a unilateral process the amplitude of the diaphragmatic movements on the affected side was about average in 1 case, slightly or moderately reduced in 9 and markedly reduced in 8 cases (Figs 1, 3, 4 and 6) On the contralateral side the amplitude was normal in 4 cases, slightly or moderately reduced in 8, considerably reduced in 5 and increased in 1 case

In the 3 cases with a bilateral process the amplitude was slightly or moderately reduced on both sides in 2 cases and markedly reduced in one case

Costal respiratory movements The form of the costal movement waves was normal on both sides in 15 cases and irregular or step formed in 2 cases In one case the waves were plateau shaped on one side and had step form on the contralateral side In 2 cases the costal movements were paradoxical on both sides and in one case they had step form on one side and were paradoxical on the contralateral side



a b

Fig 4 Same case as in fig 3 six weeks later residual minor densities at right base Kymography in ordinary (a) and deep (b) respiration Normal waveform slightly reduced diaphragmatic amplitude on the right as compared with the left side Normal costal amplitude bilaterally (arrows)

Of the 18 cases with a unilateral process the costal amplitude on the affected side was about average in 5 cases, slightly or moderately reduced in 8 markedly reduced in 4 and increased in one case (Figs 1, 3 5, and 6) On the contralateral side the amplitude was about average in 8 cases slightly or moderately reduced in 5 markedly reduced in 2 and increased in 3 cases

In the 3 cases with bilateral changes the amplitude was about average on both sides in one case and moderately reduced in a further case in the third case the amplitude was normal on one side and moderately reduced on the other side

The costal and diaphragmatic amplitudes were equal on both sides in 11 cases, in the remaining 10 cases the side of the more reduced amplitudes generally corresponded to the side of the pulmonary process

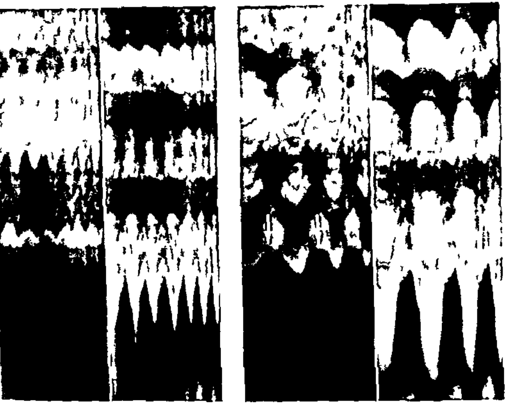


a

b c

Fig 5 Small pleural effusion on the right side 3 days after operation for perforated appendix a) Right decubitus b) and c) Kymography in ordinary and deep respiration Step-formed diaphragmatic waves bilaterally with a tendency to plateau formation in ordinary respiration (arrows) Slightly reduced diaphragmatic amplitude and increased costal amplitude bilaterally

No appreciable differences in wave form or amplitude of diaphragmatic or costal respiratory movements were observed in the various pulmonary conditions



a b

Fig 6 Right basal bronchopneumonia 2 days after laparotomy for right abdominal hernia Kymography in ordinary (a) and deep (b) respiration Plateau shaped diaphragmatic waves with markedly reduced amplitude on the affected right side in deep respiration (arrows) Waves slightly step formed but of normal amplitude on the left side Normal costal respiration bilaterally

Discussion and Conclusions

The form of the diaphragmatic movement waves was normal in the majority of cases but in a quarter of the cases it was in step form indicating some disturbance during the expiration phase Of the two cases with bilateral diaphragmatic plateau waves with moderately reduced amplitude one was a case of pulmonary embolism 10 days after laparotomy for ileus and the other had pneumonia 6 days after resection of the caecum for carcinoma The third case with plateau waves and markedly reduced amplitude on the right side developed bronchopneumonia 2 days after laparotomy for right abdominal hernia (Fig 6) Postoperative peritoneal irritation which was general in the first two cases and local in the last case may explain the kymographic appearances

The amplitude of the diaphragmatic respiration was reduced in all but one

of the cases and was equal on both sides in half the cases In the other half of the cases the difference of amplitude between the two sides was usually small The reduction of amplitude was considerable in 9 cases

The form of the costal waves was normal in the majority of cases and ab normal only in 4 cases Paradoxical costal movements in three cases suggested paralysis of intercostal muscles All three cases had a pleural effusion with parenchymatous infiltrations

The amplitude of the costal respiration was reduced in two thirds of the cases on the affected side and in about one third of the cases on the contra lateral side The degree of amplitude reduction was generally slight or moder ate

It would appear that the proportion of cases with normal and abnormal diaphragmatic waveforms as shown by kymography is similar in postoperative pulmonary complications to those observed in primary acute pulmonary con ditions Plateau shaped waves are, however, as might be expected, more frequent in post laparotomy cases A reduction in diaphragmatic amplitude *appears to be a constant finding in postoperative cases whereas in primary* pulmonary conditions it was present only in about three quarters of the cases Moreover, the relative frequency of marked reduction was considerably higher in the first group This is in agreement with the view that diaphrag matic guarding is an important etiologic factor in pulmonary complications following laparotomy

The waveform and amplitude of the costal respiratory movements were approximately similar in the two groups of conditions except for paradoxical costal movements in some postoperative cases

SUMMARY

The results of kymographic investigations of the diaphragmatic and costal respiratory movements in 21 cases of postoperative pulmonary complications are described Reduction of the diaphragmatic amplitude is a constant finding and the relative frequency of marked reduction is higher as compared with primary acute pulmonary conditions Plateau shaped diaphragmatic waves in 3 cases suggest postoperative peritoneal irritation

ZUSAMMENFASSUNG

Die Resultate der kymographischen Untersuchungen der Zwerchfell und Rippen At mungsbewegungen in 21 Fallen von postoperativen Lungenkomplikationen werden beschrie ben Eine Reduktion der Zwerchfell Amplitude ist ein standiger Befund und die relative Haufigkeit von markanter Reduktion ist grosser im Vergleich mit den primaren akuten *Lungenerkrankungen* Plateau formige Zwerchfell Kurven in 3 dieser Falle zeigen einen postoperativen Reizzustand des Peritoneums an

RÉSUMÉ

Les résultats d examens kymographiques des mouvements respiratoires du diaphragme et des côtes dans 21 cas de complications pulmonaires post opératoires sont présentés Une réduction de l amplitude diaphragmatique est un fait constant et la fréquence relative de

réduction marquée est plus élevée en comparaison avec des maladies aigues primaires des poumons Des courbes diaphragmatiques en plateau dans 3 cas indiquent une irritation péritonéale post opératoire

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FROM THE ROENTGEN DEPARTMENT (DIRECTOR PROF J FRIMANN DAHL), ULLEVAL HOSPITAL, OSLO, NORWAY

CHANGES IN THE TRANSVERSE COLON FOLLOWING PARTIAL GASTRIC RESECTION

by

GABRIEL STIRIS and KJELL TRAETTEBERG

Changes following gastrectomy and resection of the proximal part of the small intestine have formed the subjects of numerous investigations although it would appear that little attention has been paid to the influence of such operations upon the transverse colon

Six hundred and thirty cases were subjected to gastrectomy and were later examined roentgenologically at this hospital during the period 1957—60 Sixty eight of these that were free from any lesion that might have influenced the position of the large bowel were examined by means of a barium enema and form the material of the present report Information was available in most of the cases on the technique of the operation

It soon became evident during the study of this material that the left side of the transverse colon was frequently pulled up in the form of a hoop (Fig 1) towards the site of the resection The degree of this deformity varied from a slight apparently quite fortuitous, elevation of the transverse colon to marked angulation cranially, under the gastric stump or somewhat medially to it

When the large bowel has been filled with contrast medium both flexures and the transverse colon usually rise in the abdominal cavity and may mask a change of position following gastric resection However, when the contrast medium has been evacuated and the large bowel again sinks down in the

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a



b



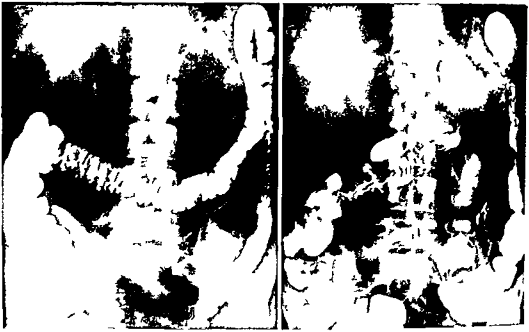
c

Fig 1 a) and b) Barium enema in cases of gastrectomy The left side of the transverse colon is pulled up towards the site of the gastric stump c) Appearance after evacuation of the bowel

abdominal cavity a relative fixation of the transverse colon in the region of the gastric anastomosis becomes evident The deformity of the colon generally lies to the left of the spine although it may occasionally be situated at or to the right of the midline

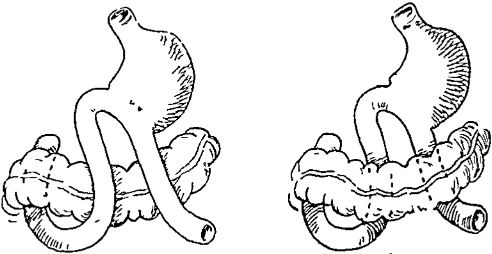
The authors have failed to demonstrate these appearances in cases that have not undergone gastrectomy Examinations of 100 control cases often revealed a convexity upwards of the transverse colon during the filling stage but it disappeared after the transverse colon had descended to a normal position after evacuation (Fig 2)

In the follow up series of 68 cases that had been subjected to gastric resection 2 cases had been operated upon by the Billroth I method and no postoperative changes in the colon were found 55 cases had been operated upon by the Billroth II method four with retrocolic and 51 with antecolic resection and in 49 of the latter postoperative changes in the colon were demonstrated The method of operation was unknown in 11 cases and in 9 of these there were post operative changes



a b

Fig 2 Colon before (a) and after (b) gastrectomy



a b

Fig 3 Schematic drawing of antecolic (a) and retrocolic (b) anastomosis by the Billroth II method



Fig 4 Contrast medium in the gastric stump and in the colon to show marked deformity of the transverse colon in high gastrectomy

Postoperative changes in the transverse colon following gastric resection with antecolic anastomosis by the method Billroth II are thus almost a regular finding A schematic representation of this operative technique (Fig 3a) shows that the transverse colon is enclosed from below by the afferent loop of the small gut and elevated in such a way that the transverse colon becomes hoop shaped It seems that the shorter the afferent loop of the small gut and the higher the resection is placed in the stomach the greater will be the post operative deformity of the transverse colon (Fig 4)

Such postoperative changes may cause difficulty in the differential diagnosis and it is therefore important that the technique be carried out carefully when examining the large bowel of subjects who have undergone gastric resection It is most necessary to pay special attention to obtaining adequate contrast filling of the transverse colon with maximal distension of the intestinal lumen The changes may easily be mistaken for adhesions infiltrations or strictures

We made careful enquiries regarding symptoms in the follow up controls These all appeared to be vague and we were unable to reach any definite conclusions

SUMMARY

An investigation of a 4 year material of 68 cases subjected to gastrectomy demonstrated post operative changes in the transverse colon The changes were evident in cases in which an antecolic anastomosis by the Billroth II method had been performed and never in cases with a retrocolic anastomosis

ZUSAMMENFASSUNG

Die Falle von Magenresektion wahrend eines Zeitraumes von vier Jahren zeigten post operative Veranderungen im Querkolon Die Veranderungen sind beschrankt auf die Falle in denen die Anastomose vor und nicht hinter dem Kolon vorgenommen wurde

RÉSUMÉ

L étude des gastrectomisés d une période de quatre ans a montré des modifications post opératoires du colon transverse Ces modifications sont évidentes dans les cas d anastomose précolique de l opération de Billroth II et n existent jamais dans les cas d anastomose rétrocolique

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FROM THE ROENTGEN DEPARTMENT (TEMPORARY DIRECTOR DOCENT PEKKA SOILA),
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COMPARATIVE STUDY OF DIFFERENT METHODS OF EVACUATION OF THE LARGE BOWEL FOR ROENTGEN EXAMINATION

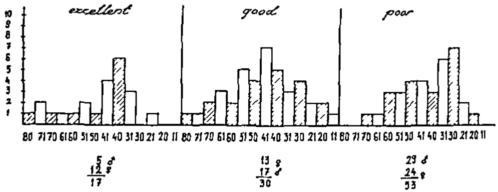
by

PEKKA SOILA and UNO WEGELIUS

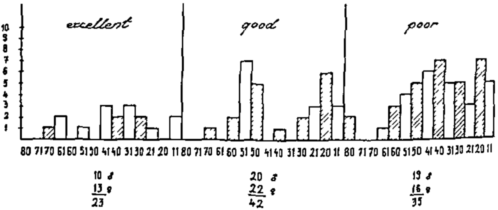
The important practical problem of evacuation of the large bowel for roentgen examination of the intra and retroperitoneal organs has lately enjoyed some attention WELIN (1958) employed a special procedure in which a contact laxative Clysodrast Novum (4 4 diacetoxidiphenylpyridil (2)-methane and tannin) was incorporated in an enema More recently its pyridil (2) methane component (SCHMIDT 1953, SCHAAL & BACHOR 1953) known under the trade names Dulcolax® or Metalax®, has been used in the form of pills and suppositories KOHLER & TAHTI (1961) claimed that an acceptable result was obtained in 65 per cent of the cases prepared in this way BARTH (1953) KOLSHORN (1954), SCHLEGEL (1954) OHLING (1955) MIES (1957) HINTZE (1957), EKLOF (1958) also reported favourable results EDLING & EKLOF (1961) stated however that no pills and suppositories can produce sufficient evacuation of the large bowel with the exception of those cases in which it is contraindicated an enema should always be administered

We have performed a further comparative investigation in continuation of previous studies (SOILA 1956)

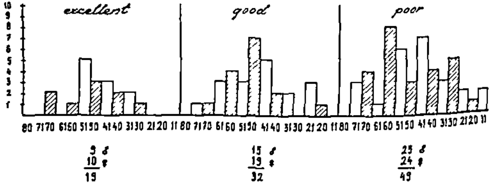
Submitted for publication 18 June 1962



Series 1

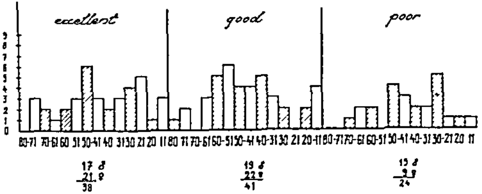


Series 2

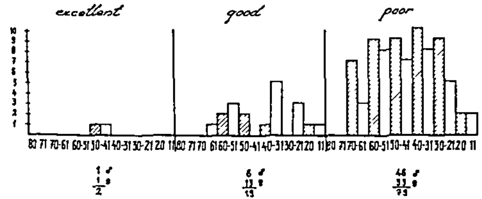


Series 3

Fig 1 Graphical evaluation of the results obtained in the different series (1) with one Dulcolax suppository (2) with two Dulcolax suppositories (3) with two tablets and one Dulcolax suppository (4) with an enema of 1.5 to 2 l of 10° C water mixed with 5 g tannin/l (5) control group (See also opposite page)



Series 4



Series 5 (Control)

Fig 1 For legend see opposite page

Material and Methods One Dulcolax suppository was given in one series (1) and two Dulcolax suppositories were given in another series (2) Two tablets and one Dulcolax suppository (series 3), and an enema of 1.5 to 2 litres water at 10 °C with 5 g tannin (= tannic acid) per litre (series 4) were given in two further series A series (5) in which the cases were not prepared at all served as control Each of the series comprised 100 cases making a total material of 500 cases

Experience has shown that the results are not always uniformly satisfactory in those cases in which the preparation of the case is undertaken outside the roentgen department Enemas were therefore administered at the roentgen department immediately before the examination

Table 1

Statistical evaluation of the results by the χ^2 test
(Each one of the methods compared with one of the others)

		Degree of freedom	Significance P<
Series 4	against series 2	8 72	0 02
4	1	23 64	0 001
4	3	22 68	0 001
2	1	6 56	0 05
2	3	4 08	0 2
1	3	0 36	9 9

The cases were treated in the out patient department of an active general hospital Bedridden cases were consequently excluded, they would appear to constitute a special problem

The results were evaluated by two radiologists in continuous joint session Complete evacuation of the large bowel was recorded as 'excellent', cases with some residue were labelled as good preparation' and if there was sufficient residue to interfere with the evaluation of the films the result was considered poor Examinations of the biliary tract, lumbar spine, and kidneys, as well as angiographic examinations of the abdominal organs, were included Barium enema examinations were excluded because of their different nature and because the disturbing effect is caused by intestinal gas

Results

The numerical results are presented in the form of graphs in Fig 1 A statistical analysis was also carried out by employing the χ^2 test The result obtained with each one of the methods was plotted against one of the other methods and the difference stated in terms of significance (Table 1) The percentage of 'excellent and good preparations in each series was also recorded (Table 2)

A possible difference between the sexes as well as between the age groups was investigated by a χ^2 test but no significant differences were found

The analysis of the results reveals that an acceptable evacuation was obtained with the tannin enema in 77 per cent of cases Two Dulcolax suppositories, produced an acceptable result in 65 per cent of cases, 2 tablets and one Dulcolax suppository in 51 per cent, and one Dulcolax suppository in 45 per cent of cases Acceptable results were recorded in 21 per cent of the controls

In evaluating the results, it should be borne in mind that the enema was given by the experienced personnel of the roentgen department and there was no delay in the subsequent roentgenologic examination It is recognized that a delay of from half an hour to one hour may result in an accumulation

Table 2

Percentage of acceptable results obtained in the different series (excellent and good taken together)

Tannin enema (series 4)	77
Two Dulcolax suppositories (series 2)	65
Two Dulcolax tablets + one suppository (series 3)	51
One Dulcolax suppository (series 1)	47
No preparation (control group)	21

of intestinal gas with deleterious effect on the examination No undesirable side effects were produced by the Dulcolax preparations but some of the subjects given a tannin enema complained of a certain amount of abdominal pain during the procedure

Discussion

It does not appear to be possible at present to obtain efficient evacuation of the large bowel by employing tablets and suppositories alone We agree with EDLING & EKLOF who by the continued evaluation of various procedures arrived at the conclusion that an enema is unavoidable for proper evacuation

KOHLER & TAHTI mentioned that their procedures were carried out in the wards and that this fact may have influenced their somewhat unfavourable results This is most certainly true, not only as regards the thoroughness of the preparation but also in the time delay between the preparation and the examination

The sex and age of the subjects in our series did not appear to affect the results KOHLER and TAHTI arrived at a similar conclusion

The remaining 23 per cent of cases in the best (tannin enema) group constitute a problem not yet solved More research should obviously be carried out with the purpose of diminishing the proportion of these unfavourable results Active methods to eliminate the intake of air into the alimentary tract and of emptying the bowel by pitressine have been suggested Although such methods appear to be fairly effective they involve a certain risk of side effects (VUORINEN et coll 1961, KLAMI & VUORINEN 1962)

SUMMARY

A comparative study of various methods employing Dulcolax suppositories and pills and tannin enemas revealed that the latter are significantly more effective for evacuation of the large bowel

ZUSAMMENFASSUNG

Eine Vergleichsuntersuchung zwischen der Anwendung von Dulcolax in Form von Suppositorien und Pillen und zwischen Tanninenlaufen ergab dass die Tanninenlaufe die bessere Darmentleerung des Dickdarmes ergeben

RÉSUMÉ

L étude comparative de diverses méthodes utilisant les suppositoires de Dulcolax et les pilules et les lavements au tanin a montré que cette dernière méthode est nettement plus efficace pour la défécation du gros intestin

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AUS DEM INSTITUT FÜR MEDIZINISCHE OPTIK (VORSTAND PROF H SCHOBER) DER
UNIVERSITÄT MUNCHEN, DEUTSCHLAND

MESSUNG DER KONTRASTÜBERTRAGUNGSFUNKTION VON RÖNTGENVERSTARKERFOLIEN

von

MANFRED HOFERT

In einer Arbeit von SCHOBER & HOFERT (1963) wurde gezeigt daß sich die fur die Kennzeichnung der Abbildungsgute in der Optik erfolgreiche Messung der Kontrastubertragungsfunktion (KÜF) auch auf verschiedene Probleme der Radiologie anwenden laßt Man kann beispielsweise zur Bestimmung der KÜF von Verstarkerfolien ein Verfahren entwickeln, das den Kontrastabfall bei der Wiedergabe von Sinusrastern konstanten Strahlungskontrasts in Abhangigkeit von der Raumfrequenz darstellt

Eine wichtige Voraussetzung der Anwendbarkeit der Übertragungstheorie ist die Linearitat der Abbildungsprozesse die beim Rontgenleuchtschirm in weiten Bereichen erfullt ist Bei Benutzung von Verstarkerfolien in Verbindung mit einer photographischen Schicht bestehen jedoch wesentlich kompliziertere Verhaltnisse denn der Film als „Bildauffanger ist weder ideal noch linear d h neben einer Kontrastverminderung besteht kein linearer Zusammenhang zwischen der aufgepragten Intensitat und der Schwarzung bzw Transparenz In der Praxis kann man aber hier ebenfalls aus folgenden Grunden brauchbare Ergebnisse erzielen einmal wurde durch Versuche bestatigt daß das Folienpaar wie auch der Leuchtschirm linear arbeitet Da die Filmunscharfe etwa

Bei der Redaktion am 26 Januar 1962 eingegangen

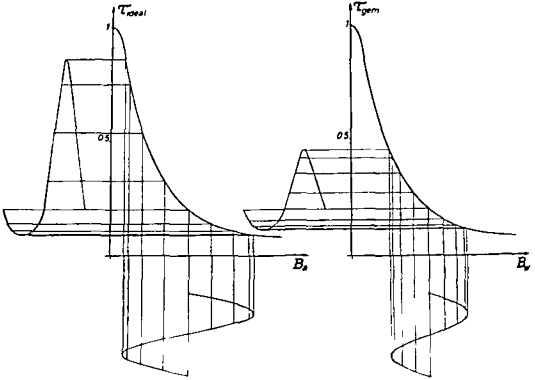


Abb 1 Verzerrung der aufbelichteten Intensitat Ba durch die nichtlineare Schwarzungskurve (links) sowie Verminderung des Kontrasts durch die photographische Schicht und Umrechnung auf die wirksame Belichtung Bu (rechts)

um eine Großenordnung niedriger als die Folienunscharfe liegt, darf man in sehr guter Naherung den Film der Folie gegenuber als idealen Bildauffänger (KÜF = 1 fur Raumfrequenzen bis etwa 10 pro mm) ansehen und die Folieneigenschaft als unabhangig vom Film betrachten Weiterhin laßt sich eine Linearisierung des photographischen Prozesses durch folgende Überlegungen erreichen

Bei Beschrankung auf den linearen Teil der Schwarzungskurve hat man den bekannten Zusammenhang

$$S = \gamma \log B$$

wobei die Belichtung B der aufgefallenen Energie entspricht,

S ist die Schwarzung, definiert als $S = \log \frac{1}{\tau}$

τ ist die Transparenz, d h das Verhaltnis des bei der Photometrierung des belichteten und entwickelten Films durchgelassenen Lichts gegenuber dem Wert an einer unbelichteten Stelle,

γ schließlich ist die Gradation oder Steilheit des Films, bei Rontgenfilmen meist ≥ 3

Bei der Ausphotometrierung mißt man einen Ausschlag am Instrument, der proportional τ ist, aber, wie man leicht nachrechnet, keine lineare Verknüpfung mit der Belichtung B zuläßt.

Die eben gemachten Überlegungen versagen jedoch vollständig im Bereich des Durchhangs, wo gerade in der Röntgenphotographie oft noch wichtige Details liegen, weshalb man ein anderes Verfahren anwenden muß.

Zusammen mit den Sinustesten zur Ermittlung der KÜF eines Folienpaares belichtet man dem Film eine Schwärzungstreppe auf.

Nach der Entwicklung trägt man die gemessene Transparenz der Treppe τ über der bekannten Belichtung B auf (Abb. 1) und ordnet nun über die B-τ-Kurve jedem photometrischen Kontrast einen Strahlungskontrast zu (HENDEBERG 1960).

Die aufgeprägte Belichtung sei

$$B_a(x, u) = B_1 (1 + \sin 2\pi u_0 x) + B_2$$

wobei u_0 eine feste Raumfrequenz,
x die Ortskoordinate auf Folie und Film,
B_2 eine gewisse notwendige Grundintensität oberhalb des Schleiers ist, da sonst kein eindeutiger Zusammenhang zwischen B und τ besteht.

Mit B_1 als der zu variierenden Belichtung ergibt sich als Strahlungskontrast des Sinusrasters

$$C_a = \frac{Ba_{max} - Ba_{min}}{Ba_{max} + Ba_{min}} = \frac{B_1}{B_1 + B_2}$$

Über die Transparenzkurve wird man nun ein gewisses τ_{min} einem Ba_{max} und ein τ_{max} einem Ba_{min} zuordnen.

Man sieht in Abb. 1 wie der Sinus in charakteristischer Weise verzerrt wird und zwar links für eine ideale Film-Folienkombination. Mit dem Photometer mißt man jedoch ein τ_{gem}, d. h. der gemessene photometrische Kontrast ist wie im rechten Teil der Abbildung ersichtlich kleiner als der aufgeprägte: die Film-Folienkombination bedeutet also eine Kontrastverminderung. Man rechnet nun über die B-τ-Kurve aus dem gemessenen photometrischen Kontrast einen fiktiven Strahlungskontrast aus. FRIESER (1958) nennt die so zugeordnete Belichtung die wirksame Belichtung Bw und erhält damit als wirksamen Strahlungskontrast

$$C_w = \frac{Bw_{max} - Bw_{min}}{Bw_{max} + Bw_{min}}$$

Durch Einführung der wirksamen Belichtung Bw ist ein linearer Zusammenhang mit der aufgeprägten Belichtung Ba hergestellt. Man definiert als Kontrastübertragungsfaktor für die Frequenz u (ohne die Phase zu berücksichtigen) das Verhältnis

$$k(u) = \frac{C_w(u)}{C_a(u)}$$

und normiert so, daß $k(0) = 1$ gesetzt wird.

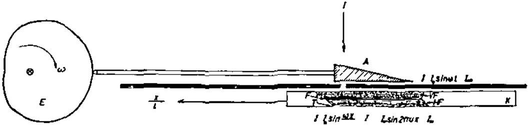


Abb 2 Schematische Darstellung der Apparatur zur Herstellung von Rontgensinusrastern

Ist speziell $C(u)$ konstant fur alle aufbelichteten Frequenzen u, so laßt sich der Betrag der KÜF $k(u) = C_w(u)$ mit der Normierung $k(0) = 1$ direkt messen

Die bisherigen Verfahren zur Ermittlung eines Gutefaktors von Rontgen verstarkerfolien bezogen sich lediglich auf die Messung von Zeichenscharfe und Kontrast Beide Begriffe sind in subjektiver Hinsicht eng miteinander ver knupft (Schober 1958) Große Kontraste tauschen oft eine scheinbare Scharfe vor, wahrend kontrastarme scharfe Details leicht als unscharf empfunden werden Es muß weiterhin noch an das bekannte Mach sche Phanomen erinnert werden welches in physiologisch optischer Hinsicht bei der subjektiven Er fassung einer Foliengute stark erschwerend wirkt

Rohler (1957 1958) hat deshalb schon fruher darauf hingewiesen, daß eine vernunftige Unscharfendefinition weder uber die subjektive Empfindung noch uber die Schwarzung des durch das Folienlicht belichteten Films, sondern nur durch Umrechnung auf die Dosis d h die Belichtung, moglich ist Er gibt als objektives Meßverfahren die Kantenmethode an, welche z B auch von Frost (1957) und von Frommhold (1956) benutzt wurde Dabei wird eine Bleikante auf Folie und Film aufgelegt und belichtet, wobei die Bleifolie so dunn sein muß daß unter ihr der Film noch merklich geschwarzt wird und so aus dem Schleier kommt

Nach der Ausphotometrierung des Films und Umrechnung der Schwarzung auf die Dosis werden die Abzissenwerte aufgesucht, in denen die Unscharfe kurve der Kante 10 % bzw 90 % ihres Gesamtanstieges erreicht Der Abstand dieser beiden Werte mißt dann die Unscharfe Dies Verfahren hat jedoch den Nachteil großer Ungenauigkeit Man kann nicht mit Sicherheit zwischen ver schiedenen Folientypen unterscheiden

Ein anderes Meßverfahren besteht in der Abbildung feiner rechteckiger Metallraster mit Rontgenstrahlen und Messung des Kontrastabfalls mit ab nehmender Strichbreite Diese Methode ist dann genauer, wenn viele Raster elemente vorhanden sind und sich so willkurliche Schwankungen in Filmemul sion und Folie herausheben Pfahnl (1956, 1957) und Roth (1961) verwen deten dieses Prufverfahren, bei dem sich die Unscharfe des ersten Verfahrens aus dem Abfall des Kontrasts der Rechteckraster mit wachsender Frequenz berechnen laßt, falls man annimmt, daß die Unscharfekurven Gaußverteilungen entsprechen

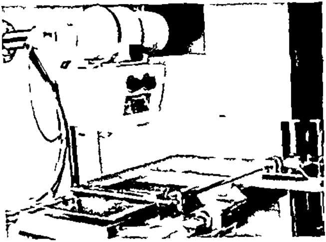


Abb 3 Versuchsaufbau

Medizinisch interessante Details liegen in ihrer Größe im Bereich von 10 bis etwa 0,5 mm (kleinere Strukturen z B Knochenrisse werden besser mit folienlosen Filmen aufgenommen) und dort interessiert es vor allem ob eine Verstärkerfolie kleine Kontraste schon nivelliert oder noch sichtbar werden läßt Deshalb ist es sinnvoll, Raster zu verwenden und bei einem konstanten Objektkontrast die Verschmierung des Bildkontrasts mit abnehmender Strichbreite zu untersuchen Die Darstellung eines derartigen Kurvenverlaufs ist zur Beschreibung eines Folienpaares vernünftiger als die Angabe einer einzigen Zahl

Der Nachteil dieser Verfahren liegt in der Schwierigkeit solche Metallraster mit ausreichender Genauigkeit herzustellen Neben einem bekannten und gleichmäßigen Objektkontrast müssen diese auch bei hohen Frequenzen gute Genauigkeit und genügend Stege zur Herausmittelung statistischer Schwankungen besitzen

Will man die Kontrastübertragungstheorie auf die Verstärkerfolie anwenden so sind dazu günstigerweise Sinusraster bezüglich der Dosis (Belichtung) auf Folie und Film zu belichten Zwar kann man auch Rechteckraster benutzen, doch läßt sich auch bei denen die den vorstehenden Anforderungen genügen die Umrechnung auf Sinusraster nur näherungsweise durchführen

Die Angabe der KÜF als objektives Maß für die Güte einzelner Folienpaare erfordert also die Aufbelichtung von Sinusrastern und die Messung des Kontrastabfalls mit wachsender Raumfrequenz

Abb 2 und 3 zeigen Prinzip und Ausführung einer Apparatur zur Herstellung von Röntgensinusrastern Eine Kassette mit Film *F* und Folienpaar *VF* und *HF* wird mit konstanter Geschwindigkeit *v* unter einem Spalt aus Wolframblech (Breite 0,1 mm) bewegt Dieser wird durch einen Aluminiumkeil *A* von oben mit einer Röntgenstrahlungsdichte *I* bestrahlt Wenn nun der Keil in geeigneter Weise bewegt wird, so läßt sich unter ihm die Strahlungsdichte

bezuglich der Zeit sinusformig variieren und damit auf dem Film eine der Transportgeschwindigkeit v der Kassette und der Schwarzungskurve ent sprechende Transparenzverteilung erzeugen Mit Annahme des Schwachungs gesetzes

$$I = I\ e^{-\mu z}$$

(durch genugende Vorfilterung laßt sich das Rontgenspektrum homogenisieren, d h es darf mit hinreichender Genauigkeit mit einem konstanten μ gerechnet werden) ergibt sich als Bedingung, daß ein Keil mit exponentiell verlaufender Dickenvariation gleichformig mit Hilfe eines Exzenters uber dem Spalt be wegt werden muß Da sich ein solcher Keil jedoch mechanisch schwer her stellen laßt, wird ein linearer Aluminiumkeil verwendet, der nun aber entsprechend verschoben werden muß Fur die Bewegung ergibt sich folgende Bedingung

Ist z die Keildicke an einer beliebigen Stelle, y die Koordinate in der Langs richtung des Keils und α der Keilwinkel, so ist die Strahlungsdichte an jedem Punkte unterhalb des Keils gegeben durch

$$I = I\ e^{-\mu z} = I\ e^{-\mu\ \mathrm{tg}\,\alpha\, y}$$

Andererseits soll auch gelten

$I = I\ \sin\omega t + I_m$ (I_m ist hinzugefugt da I immer positiv und muß so groß sein dass der Film bei minimaler Rontgeneinstrahlung noch aus dem Schleier gehoben wird)

Somit ergibt sich als Forderung

$I\ e^{-\mu\ \mathrm{tg}\,\alpha\, y} = I_e \sin\omega t + I_m$ oder nach $y(t)$ aufgelost

$$y = -\frac{1}{\mu\ \mathrm{tg}\,\alpha} \ln\left(\frac{I}{I} \sin\omega t + \frac{I_m}{I_e}\right) \text{ mit geeigneten Konstanten}$$

$$y(t) = -C_1 \ln(C_2 \sin\omega t + C_3)$$

Diese konnen durch Wahl des Hubs des Keilwinkels usw empirisch festgelegt und den Erfordernissen bezuglich des aufzubelichtenden Kontrasts angepaßt werden

y (t) wird als Abstand von einer Achse in Polarkoordinaten dargestellt

Die so gewonnene Modulationskurve E rotiert mit der Winkelgeschwindig keit ω und durch Anpressen einer Schubstange an diese laßt sich die Bewegung des Keils A so steuern, daß unter ihm die Intensitat mit

$$I = I_e \sin\omega t + I_m \text{ variiert}$$

Da sich die Kassette K mit einer gleichformigen Vorschubgeschwindigkeit v bewegt, erhalt man unter dem Spalt die Raumfrequenzen $u = \frac{\omega}{2\pi v}$ in Ab hangigkeit von der Winkelgeschwindigkeit der Modulationskurve

Der Einfluß des Belichtungsspaltes laßt sich mit Hilfe der Übertragungs theorie berechnen Er stellt bezuglich des aufbelichteten Strahlungskontrasts ein Filter fur hohe Raumfrequenzen dar Nimmt man an, daß der Spalt der

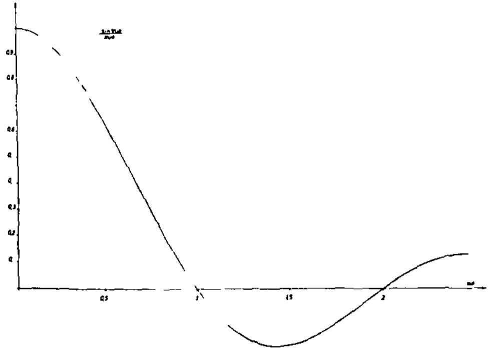


Abb 4 Normierte Spaltfunktion $\frac{\sin x}{x}$ Übertragungsfunktion eines Spaltes der Breite a für die Frequenz u

Folie direkt aufliegt, so kann man seine geometrische Vergrößerung auf Grund der Zentralprojektion vernachlässigen

Ist etwa $B(x)$ die Strahlung unterhalb des Keils so ergibt sich die Strahlungsdichte $I(x)$ hinter dem Spalt endlicher Breite a als Faltung von $B(x)$ mit der Durchlässigkeitsfunktion $T(x)$ des Spaltes oder einfacher mit den Bezeichnungen in der Frequenzdarstellung $i(u) = t(u)\ b(u)$ (SCHOBER & HOFERT 1963)

Nimmt man an daß durch saubere Ausblendung der Spalt ein kastenförmiges Intensitätsprofil aufweist, d h

$$T(x)=1 \text{ für } -a/2 \leq x \leq a/2 \text{ und } T(x) = 0$$

in allen übrigen Bereichen ist, so läßt sich die sog normierte Spaltfunktion $t(u)$ (Division durch die Spaltbreite a) berechnen

$$t(u) = \frac{1}{a} \int_{-\infty}^{+\infty} e^{2\pi ux}\, dx = \frac{\sin \pi ua}{\pi ua}$$

Diese Funktion ist in Abb 4 dargestellt Man sieht, daß durch eine Öffnung von 1/10 mm Breite eine Raumfrequenz von 10 pro mm nicht mehr über

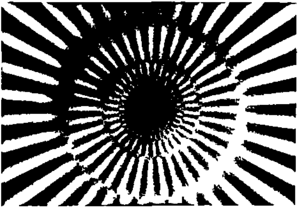


Abb. 5. Unscharfe Aufnahme eines Siemenssterns

tragen werden kann. Oberhalb dieser Frequenz tritt die Erscheinung der Phasenumkehr auf, es wird eine periodische Struktur aufbelichtet, die bei vermindertem Kontrast an den Stellen des Schwärzungsmaximum nun ein Minimum aufweist. Geometrisch läßt sich diese Pseudostruktur durch Überlagerung von Halbschatten erklären und tritt z. B. auch bei unscharfen Aufnahmen des Siemenssterns auf (Abb. 5).

Während in den folgenden Experimenten der Einfluß des Spaltes bei hohen Frequenzen als Korrektur berücksichtigt werden muß, kann die Fokusunschärfe durch die Wahl der Versuchsbedingungen vernachlässigt werden. Damit man über die früher erwähnte B-τ-Kurve eine Beziehung zwischen Schwärzung und aufbelichtetem Kontrast hat, wird neben verschiedenen Raumfrequenzen mit jedem Folientest auch eine Schwärzungstreppe aufbelichtet und gleichzeitig entwickelt.

Einige Ergebnisse der Versuche sind auf den Abb. 6, 7 und 8 zu sehen. Als Beispiel werden drei handelsübliche Folien der Typen hochverstärkend (H), universal (U) und feinzeichnend (F) untersucht. Man erkennt in Abb. 6 die unterschiedlichen KÜF. Daneben wird auch eine Prüfung der Kontrastabnahme für Rechteckraster mit zunehmender Strichzahl durchgeführt. Da das aus 1/10 mm Bleifolie geschnittene Testobjekt nur drei Stege bei neun verschiedenen, festen Raumfrequenzen besitzt, ist besonders für die hohen Frequenzen keine vernünftige Herausmittelung statistischer Fehler möglich. Die mit Rechteckrastern gewonnene Funktion soll nach der Theorie bei niedrigen Raumfrequenzen oberhalb der KÜF liegen. In Abb. 7 zeigt die Kurve UR auch den erwarteten Verlauf gegenüber U. Eine Umrechnung dieser beiden Kurven ineinander ist nur näherungsweise möglich, wegen der erwähnten Ungenauigkeit aber wenig sinnvoll.

Da die KÜF und das Punktbild wie früher erwähnt über die Fouriertransformation zusammenhängen, kann man die Form des Zerstreuungsbildes $S(x)$ aus $s(u)$ berechnen. Dabei bleibt in Ermangelung eines Rechenautomaten nur

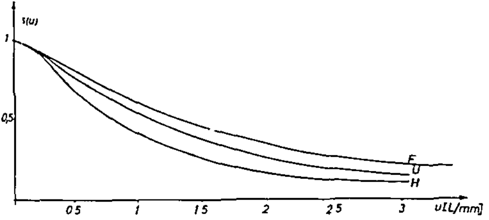


Abb 6 Vergleich der KÜF von feinzeichnender (*F*) Universal (*U*) und hochverstärkender Folie (*H*)

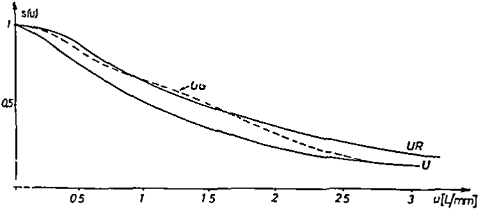


Abb 7 Vergleich der KÜF mit der Kontrastabnahme bei einem Rechteckraster (*UR*) fur die Universalfolie

die Moglichkeit die gemessenen Kurven *H* *U* und *F* durch analytische Funktionen deren Fouriertransformierte bekannt ist, anzunahern Bei der Zerstreuungsfigur des Punktbildes laßt sich etwa im Anschluß an die fruheren Messungen zur Charakterisierung jeder Folie mit einer Unscharfemaßzahl die Halbwertsbreite der Figur angeben Rechnungen liefern fur die feinzeichnende Folie etwa den Wert 80 μ fur die Universalfolie 100 μ und bei der hochverstarkenden Folie hat man mit einer *HWB* von 140 μ zu rechnen

Genau genommen darf immer nur von der Kombination Folie Film gesprochen werden Der Einfluß des Films kann durch Verwendung der gleichen Folie mit verschiedenen Rontgenfilmen untersucht werden Man kann schon vorher sagen da uber die Schwarzungskurve auf die wirksame Intensitat um

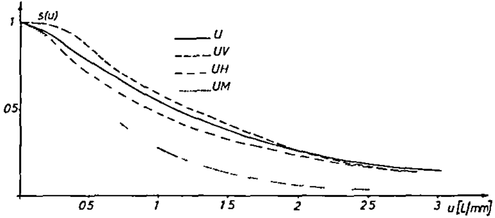


Abb. 8. Vergleich der KÜF von Vorder- und Hinterfolie (VF und HF)

gerechnet wird und damit die unterschiedliche Gradation als Einfluß entfällt, konnte sich besonders die verschiedene Körnigkeit der Emulsionen bemerkbar machen. Obgleich jedoch sowohl grobkörnige als auch sehr feinkörnige Filme benutzt werden, ergibt sich bei den Versuchen immer die gleiche Form der KÜF. Dies bestätigt nur die alte Annahme, daß bis etwa 4 Linien/mm die „Diffusionsunschärfe" der Folien sehr viel größer ist als alle anderen Einflüsse. Erst bei höheren Raumfrequenzen, bei denen sich nach den Untersuchungen von SCHOBER & KLETT (1954) nicht nur die Dicke der Leuchtschicht, sondern auch ihre Körnigkeit auswirkt, dürften auch verschiedene Filmemulsionen nicht ohne Einfluß sein.

Man muß sich auch aus noch anderen Gründen hüten, zu sagen, man habe nur die Folieneigenschaften betrachtet. Ein besonders interessantes Beispiel liefert ein Film, dessen Emulsion auf einem gelben Träger aufgebracht ist. Da jener für das blaue Folienlicht als Filter wirkt, wird praktisch jede Schichtseite nur einfach belichtet, die beiden Folienhälften sind sozusagen entkoppelt. Kurve *UG* in Abb. 7 zeigt die KÜF einer Universalfolie bei Verwendung mit Gelbschichtfilm. Man erkennt eine merkliche Verbesserung in der Kontrastwiedergabe gegenüber *U*, allerdings in Verbindung mit einer entsprechenden Empfindlichkeitseinbuße.

Eine weitere interessante Frage ist, ob der früher erwähnte Multiplikationssatz der Übertragungstheorie zwischen Folie und Film gilt. Sicherlich kann man jede einzelne Folienhälfte mit einem eigenen Faktor versehen, doch darf man diese beiden nicht miteinander multiplizieren, da die Folienseiten nicht voneinander unabhängig sind. Ein Versuch bestätigt dies sofort: Abb. 8 zeigt die gemessene Kurve für die Universalfolie *U* sowie *UV* und *UH* die gemessenen KÜF für Vorder- und Hinterfolie allein. Die Multiplikation von *UV* und *UH* liefert *UM*, ein Ergebnis, welches nicht mit *U* übereinstimmt. Viel besser würde eine Addition mit nachfolgender Normierung passen, was übrigens

leicht verständlich ist. Die Vorderfolie allein ist in ihrer Kontrastwiedergabe besser als das Folienpaar, die Hinterfolie schlechter. Die Überlagerung der beiden Unschärfen ergibt ein Ergebnis, welches zwischen *UV* und *UH* liegt.

Es ist weiter zu prüfen, inwieweit der Multiplikationssatz zwischen Folienpaar und Film gilt. Abgesehen von der Tatsache, daß die Filmschwärzung nicht allein durch das Folienlicht, sondern auch durch einen kleinen Anteil der reinen Röntgenstrahlung hervorgerufen wird, bilden Folie und Film ebenfalls eine Einheit, da der geometrische Abstand zwischen den Folien durch die Filmdicke bestimmt wird. Würde man einen extrem feinkörnigen Dünnschichtfilm, der bei etwa 4 Linien/mm eine praktisch gleich eins zu setzende KÜF besitzt, benutzen, um so nur die KÜF der Folie zu bekommen, so erhält man ein falsches Ergebnis, weil man in diesem Falle die Folien nicht unter den üblichen Bedingungen testet.

Aus diesem Grunde ist es nur zulässig, Folie und Film gemeinsam zu messen und für diese auch eine gemeinsame KÜF $s(u)$ zu definieren, zumal normale Röntgenfilme (nicht der Gelbschichtfilm) etwa die gleiche Dicke haben und im Rahmen der Meßgenauigkeit bis etwa 4 Linien/mm nicht zu unterscheiden sind.

Der Zweck dieser Arbeit sollte nicht so sehr von seiten der Möglichkeit, eine neue Größe für die Foliengüte einzuführen, gesehen werden, sondern vielmehr eine Einführung in die praktische Anwendbarkeit der Übertragungstheorie bei der Abbildung mit Röntgenstrahlen darstellen.

Für die Anregungen und Unterstützung bei dieser Arbeit möchte ich vor allem meinem verehrten Lehrer Herrn Prof. Dr. Schober sowie seinen Assistenten Herrn Dr. Röhler und Herrn Hartmann recht herzlich danken. Die Deutsche Forschungsgemeinschaft stellte den Röntgenapparat, die Firma Perutz kostenlos das Filmmaterial und die Firma Schwarzer leihweise einen Schreiber zur Verfügung, wofür ich ebenfalls meinen Dank aussprechen möchte.

ZUSAMMENFASSUNG

Es wird eine Methode zur praktischen Anwendung der Kontrastübertragungstheorie bei der Abbildung mit Röntgenstrahlen am Beispiel der Aufnahme mit Verstärkerfolien angegeben. Eine Apparatur zur Herstellung von Röntgensinusrastern wird beschrieben und die Kontrastübertragungsfunktionen verschiedener Folienkombinationen werden gemessen.

SUMMARY

A method for the practical use of the theory of contrast transfer in roentgenography is described using intensifier screens as an example. A device for producing roentgen sine grids is indicated and contrast transfer functions are measured.

RÉSUMÉ

L'auteur indique une méthode pratique de la théorie de la transmission de contraste dans la radiographie avec écrans renforçateurs. Il décrit un appareil pour la production des grilles sinus et il mesure des fonctions de la transmission de contraste pour certaines combinaisons d'écrans.

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BOOK REVIEWS

VERTEBRAL AND CAROTID ANGIOGRAMS IN TENTORIAL HERNIATIONS By Hans F Plaut 155 pages 32 illustrations and 4 tables Charles C. Thomas Springfield Illinois 1961 Price $ 10 50

The rapid advances in neuroradiology during the last decades have been based on intense research in neuro-anatomy as well as its variations and the changes that may occur in pathologic conditions It is therefore of considerable interest to receive a book that promises new aspects on this subject

The monograph deals with the angiographic changes in tentorial herniations and in this connexion the author presents a study of the anatomy of the tentorium and as stated in the preface for the first time in the literature of its roentgenographic demonstration The author s investigation of the tentorium is mainly restricted to measurements of the width and length of the tentorial incisura in cadavers and he seems to have missed the opportunity to study the anatomy of the normal tentorium in vivo with the aid of subdurally injected air There is therefore reason to question certain cases of asymmetry of the tentorial leaves which according to the author are due to pressure from expanding lesions, especially as similar cases are included in the normal autopsy material Practically no attention is paid to the influence of the projection on the appearances of the subtentorially located air The subdural space below the tentorial leaf in one case (Case 7 Fig 19e) appears narrower on the left side this being described as being due to compression by a left sided supratentorial mass In another projection (Fig 5a illustrating the same case) however this difference is no longer present and the subdural space appears to be almost wider on the left side The author seems to have an exaggerated conception of the distensibility of the tentorium when subjected to pressure A backward displacement of the straight sinus that is illustrated is thus nothing else but a normal variation.

The material of angiographically examined cases of temporal herniations consists of 15 cases 14 of which were verified at operation or autopsy or both 3 of these are the author s own cases A detailed description of the angiographic signs in 10 different types of temporal herniations is given in a comprehensive table It is obvious that this table cannot have been based on the limited material presented in this book but must have been founded on earlier reports which, it is felt could have been given more fully Furthermore the author does not seem to be aware of the technical and haemodynamic prerequisites for the angiographic examinations as shown for example by his conclusions regarding the non filling of arteries belonging to more than one supply vessel He is evidently unaware of the fact that layering of blood and contrast material may take place in the basilar artery The reader must often feel dubious as regards some of the angiographic changes described especially as they are not supported by the illustrations additional explanatory sketches would have been helpful

The book may be said to be an ambitiously planned study of the tentorium and tentorial herniations but does not appear to live up to the expectations of the reader and may be not to those of its author

Torgny Greitz

HARTSTRAHLTECHNIK Von Wolfgang Frik 144 Seiten und 100 Abbildungen Georg Thieme Stuttgart 1961 Price DM 28 50

According to the preface the book presents the fundamentals of high voltage technique and outlines its fields of application The experimental basis for the choice of kilovoltage and the practical application of techniques in various examinations is discussed the extensive bibliography at the end of the book was assembled by H Bosche

Numerous diagrams both original and borrowed, illustrate the introduction An experiment on blurr caused by motion is reported but as the wave form of the current was not taken into consideration and as this changes with various systems it would considerably have influenced the experimental result

Problems connected with the use of the high voltage technique are discussed in detail The important factors regarding screens and films are treated rather briefly and the photographic process which may influence the reproduction of contrast considerably is not discussed at all The photographic procedure which is in fact elastic has been regarded as static and no data are available regarding the density curves of the screen film combinations employed

The illustrations are moderately good but differences in the various techniques are often difficult to recognise The importance of definition is repeatedly pointed out but the author surprisingly enough uses 2 mm foci which are surely no longer acceptable the possibilities of employing smaller foci have generally been considered as one of the leading advantages of the technique discussed

Films obtained with a cobalt 60 therapy unit (gammatron 2 000 curie) with exposure times of several seconds are included These may be of certain interest although no mention is made of the dose delivered which it would appear may reach a level of 1 r per exposure

Only a few of the films reproduced were obtained at kilovoltages above 120 results from the 150—200 kV region would have added much to the instructive value

Much attention has been paid to the visual result in films obtained at different kilovoltages A correct evaluation of a technique however presupposes that all factors influencing quality are considered against all the conditions of the exposure — it appears that the author of this book has overlooked certain important details

Ove Mattsson

DIAGNOSTIK UND THERAPIE DER ERKRANKUNGEN DES MAGEN DARM KANALS IN DER MEDIZINISCHEN UNIVERSITATS-KLINIK ERLANGEN Zum 65 Geburtstage von Prof Dr N Henning 360 Seiten 148 Abbildungen und 4 Tabellen S Karger Basel 1962 Price Sw Fr 87

These papers in German from a refresher course on gastroenterology held in Erlangen in 1960 cover the gastro-intestinal tract from the oesophagus to the rectum Considerable importance is placed upon endoscopic examinations for the volume is dedicated to Prof Henning The roentgenologic aspects are well presented although there is perhaps little that can be described as new More valuable are the papers on cytology and studies of the mucous membrane

One has the impression that the subject was rather a wide one for a refresher course and might, with advantage have been more concentrated However the whole volume is well presented and is undoubtedly of interest.

J Frimann Dahl

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DECREASED LEFT LUNG VASCULARITY IN CONGENITAL LEFT TO RIGHT SHUNTS

by

JOSEPH E WHITLEY, ULF RUDHE and HARRY HERZENBERG

Reports of diffuse or partial hypovascularity of the left lung associated with congenital heart disease have appeared in the literature in the last two or three years FLEMING (1959) reported decreased vascularity of the left lung in 15 cases of atrial septal defect A similar finding was reported in 3 cases of patent ductus arteriosus by GARFUNKEL & KIRKPATRICK (1961) who initially attributed it to overaeration of the left lung, and more recently (1963) proposed a combination of overaeration and decreased vascularity as being etiologic Observations of similar disparities have been made at this institution in cases of atrial septal defect and patent ductus arteriosus as well as in ventricular septal defect and certain other conditions

In an effort to elucidate some of the roentgenologic aspects of this condition roentgenograms of the chest as well as angiocardiograms and heart catheterization data, when available, were reviewed in 104 cases of isolated ventricular septal defect 70 cases of isolated patent ductus arteriosus and 83 cases of atrial septal defect, isolated or associated with partial abnormal venous return

Material The age of the subjects at the time of examination ranged from 1 month to 16 years All cases had had at least one roentgen investigation of the chest and the diagnosis had been verified by heart catheterization and angiocardiography and/or surgical intervention Cases with ventricular and atrial

From the Roentgen and Cardiovascular Departments of the Pediatric Clinic Karolinska Sjukhuset Stockholm Sweden Submitted for publication 13 June 1962



Fig 1 Male aged 3 years with a patent ductus arteriosus and increased pulmonary vascular resistance Diminished vascularity of the left lung but no signs of hyperinflation Heart catheterization revealed a pulmonary artery pressure of 82/44 mm Hg and an aortic pressure of 80/39 An oxygen step-up from 8.2 to 10 4 volume per cent between the right ventricular outflow tract and the pulmonary artery was recorded

septal defects had had both right heart catheterization and selective angiocardiograms Ten of the patent ductus arteriosus cases had had right heart catheterization and selective angiocardiograms and 21 had had heart catheterization and/or aortography The technique of heart catheterization and angiocardiography has been described by KJELLBERG, MANNHEIMER, RUDHE & JONSSON (1959) The angiocardiograms had been routinely performed with injection of the contrast medium into the right ventricle or right ventricular outflow tract with simultaneous bi plane filming in the frontal and lateral projections The majority of cases with an atrial septal defect were examined in both oblique projections The material varied from a single chest examination to serial films and angiocardiograms at 7 year intervals There were some pre- and postoperative cases Assessment of vascularity was on a subjective basis No actual measurements of the size of the vessels were made

Results

Decreased vascularity of all or a portion of the left lung as compared to that of the right lung was evident in 16 of the 104 cases of ventricular septal defect, 10 of the 70 cases of patent ductus arteriosus and 4 of the 83 cases of atrial septal defect In none of the groups was the absolute or relative decrease in the vascular pattern uniform although the extent of involvement varied The apical segments of the left upper lobe appeared to be more affected than the rest of the lung, particularly in the ventricular septal defect cases The changes in the atrial septal defect cases were less marked and more evenly distributed than in the other cases The changes did not seem to be related to age

Marked hypovascularity of the left lung in the ventricular septal defect cases was associated with some degree of pulmonary hypertension Some cases of



a

Fig 2 Same case as in Fig 1 a) Selective angiocardiography b) and c) Magnified views of the upper zones of the lungs from the same film demonstrate a uniform narrowing of the left pulmonary arterial tree



b c

patent ductus arteriosus and atrial septal defect with frank asymmetry on the other hand, had only a minimal increase in pulmonary artery pressure which might well have been hyperkinetic in origin No stenoses of the left pulmonary artery or its branches were identified in the angiocardiograms

Fig 1 illustrates a typical case of almost uniform diminution of the vascularity of the left lung this was a case of patent ductus arteriosus with a left to right shunt Fig 2 shows narrowing of the left pulmonary artery branches at angiocardiography and Fig 3 the apparent perfect symmetry in the vascular pattern of the lungs following ligation of the ductus

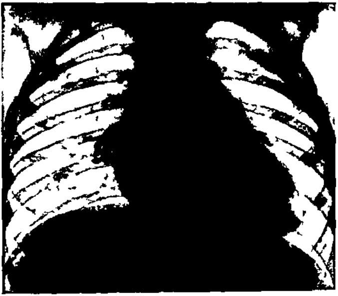


Fig 3 Same case as in figs 1 and 2 two years after ligation and division of the ductus Apparent symmetry and diminution in the over all vascularity of the lungs

Figs 4 and 5 illustrate a similar sequence in a case of ventricular septal defect The apical segments of the left upper lobe, however, appear to be more involved than the rest of the lung, and on examination following operation the return to vascular symmetry was incomplete

While this study was being carried out, hypovascularity of the left lung was seen in one case of peripheral pulmonary artery stenoses with lesions primarily confined to the left lung, four cases of more complex congenital heart lesions associated with left to right shunts, and in one case of hemihypertrophy of the body with a clinically normal heart

Discussion

Diffuse or partial hypovascularity of the left lung associated with congenital heart disease is not pathognomonic of any one entity It would appear to the writers that it has been predominantly associated with a left to right shunt or some local obstruction In one instance it was present in a case of a hemihypertrophy of the body without clinical evidence of cardiac or pulmonary disease

The changes described tended to be more marked in cases of ventricular septal defect and patent ductus arteriosus than in atrial septal defect cases The apical segment of the left lung appeared to be more affected in the former cases resulting in a somewhat asymmetric appearance of the vasculature Absence of the usual roentgen signs of hyperinflation even in severe cases, and the consistently decreased pulmonary vascularity supplying the involved lung tissue, suggest that these changes are primarily vascular in origin



Fig 4a



b

Fig 4 a) Male aged 6 years with a ventricular septal defect Sparse a c larity in the apical zone of the left upper lobe Heart catheterization demonst ated a pressu i f l 10 mm Hg in the pulmonary artery compared with a systemic pressure of 120/80 An oxygen t p-up from 10 4 to 12 7 volume per cent between the right atrium and right entricle was reco d d b and c Magnified views Narrowing of the arteries of the left lung most evident in the apical segments Transient delay in filling of th vessels of the left lung was noted



Fig 5 Same case as in fig 4 5 weeks after surgical closure of the defect Reduction of the over all vascularity and persistent narrowing of the vessels of the upper lobe Cardiac catheterization no shunt present pulmonary artery pressure 34/14 mm Hg

The cause of this vascular change is uncertain KERLEY (1958) has observed similar hypovascularity of the left upper lobe in acquired heart disease and he believed that the upper lobe vein may be compressed by distension of the pulmonary artery This could not be confirmed by angiocardiography in the present series Although complete regression appears to occur in some cases after repair of the heart lesion, it seems possible that the pulmonary artery may actually be congenitally hypoplastic Much of the post operative equalization of the vascularity of the lungs is due to reduction towards a normal flow *in the* right lung, and this fact should temper extreme criticism of this proposition Local constriction of the left pulmonary artery or its branches was not present in the cases studied by angiocardiography and therefore cannot account for the asymmetric vascular pattern SWAN et coll (1956) and FLEMING (1959) have studied in detail the physiology of the differential circulation of the lungs in atrial septal defect and have reported that in some cases the flow to the left lung was less than that to the right DOLLERY et coll (1961), using radioactive carbon dioxide have measured the flow in the upper and lower portions of the lungs in cases of congenital heart disease, including isolated cases with the left to right shunts under discussion They found a small but significant preponder

ance of flow through the upper portion of the right lung in atrial septal defect cases and almost identical flow through the two upper zones in cases of ventricular septal defect and patent ductus arteriosus The present investigation tends to show that asymmetric vascularity of the lungs is by no means exceptional in congenital heart disease Correlation of the roentgenologic physiologic and pathologic aspects of this phenomenon will probably be necessary fully to elucidate the etiologic factor or factors

Acknowledgement

This investigation was carried out during the tenure by J E W of a James Picker Foundation Advanced Fellowship in Academic Radiology at Karolinska Sjukhuset Stockholm

SUMMARY

Absolute or relative diminution of the vascularity of the left lung and particularly of the upper lobe has been observed in association with left to right shunts at the atrial ventricular and ductus levels as well as in certain other conditions The change the cause of which is unknown tended to be more marked in cases of ventricular septal defect and patent ductus arteriosus

ZUSAMMENFASSUNG

Absolute oder relative Verminderung der Gefässzeichung in der linken Lunge und besonders im linken Oberlappen wird häufig in Fallen von links nach rechts shunt bei Vorhofs- oder Kammerdefekt, bei offenem Dukt und gewissen anderen Bedingungen gefunden Der Befund dessen Ursache nicht klar ist ist mehr ausgeprägt bei Kammerseptumdefekt und offenem Dukt

RÉSUMÉ

Les auteurs ont observé une diminution absolue ou relative de la richesse vasculaire du poumon gauche et en particulier du lobe supérieur dans des cas de shunts gauche-droite au niveau des oreillettes des ventricules du canal artériel ainsi que dans certaines autres affections Cette anomalie dont l origine est inconnue a tendance à être plus marquée dans les cas de communication interventriculaire et de canal artériel persistant

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FROM UNIVERSITY CLINIC OF SURGERY II (DIRECTOR PROF VAINO SEIRO) AND THE ROENTGENDIAGNOSTIC DEPARTMENT (DIRECTOR DOCENT ROLF KOHLER) OF THE UNIVERSITY SURGICAL CLINICS, HELSINKI, FINLAND

SMALL CONTRAST MEAL EXAMINATION OF THE LARGE BOWEL IN CHRONIC CONSTIPATION

by

ROLF KOHLER

Conventional or double contrast barium enema examinations both constitute excellent means of studying the morphology of the colon Investigations of function on the other hand, which sometimes also require a detailed analysis, may well be studied with the aid of a barium meal examination The present paper reports on results achieved with the small contrast meal, previously described by the author (KOHLER 1963), in patients with chronic, painful constipation

Classification of constipation and methods of examination Chronic constipation is one of the commonest disorders of function of the human organism The literature on the subject is voluminous, and shows that the causative factors are of great diversity and complexity, and that practically every author has his own method of classification (HURST 1921, PAPE 1937, FELDMAN 1948 ALMY 1959, MACHELLA 1959) The aetiology is dealt with in a simple and lucid yet adequate manner, in SCHINZ textbook of roentgen diagnostics (1952), which distinguishes between three different causes of constipation, organic, dynamic, and combined, in the latter case an organic process extrinsic to the colon produces disorders of function of the large bowel

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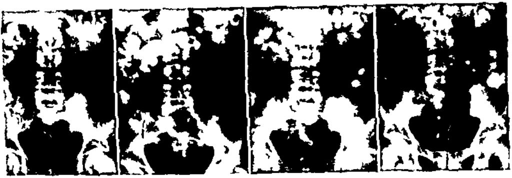


Fig 1 Small contrast meal examination in chronic painful con tipation films from the 1st 2nd 3rd and 4th days Markedly spastic left colon with considerable accumulation of faeces Owing to severe abdominal pain the bowel was evacuated by enema before the 4th day and also on the 5th



Fig 2 Small contrast meal examination in spastic constipation films from the 1st 2nd 4th and 5th days The bowel emptied on the morning of the 5th and 6th days and was thereafter devo d of contrast medium Moderate accumulation of faeces in the descending colon and the s gmoid.

When organic constipation is probable i e the cause is mechanical ob struction, a conventional or a double contrast barium enema examination is performed This makes it possible to detect positional anomalies of the large intestine strictures of an inflammatory or malignant character or destruction produced by some expansive process outside the colon or by adhesions for example

A contrast meal examination gives the best result in the examination of func tionally conditioned constipation Changes such as atony spasticity or irri tability are likely to be revealed as the cause of the constipation It is pos sible to demonstrate whether the intestinal contents tend to stagnate in the ascending or transverse colon or distally in the rectosigmoid region so-called rectal dyschesia

The current practice of administering large non standardized quantities of contrast medium and restricting the intake of fluids purely for the sake of the



Fig 3 Small contrast meal examination in chronic constipation emptying time 10 days films from the 1st 5th 7th and 9th days Slow progress of the barium meal marked left sided spasticity and accumulation of faeces

examination is less reliable (WEBER 1934) The result may be that in a not insignificant number of cases hard barium masses have to be removed manually from the rectum (KANTOR 1932) The present writer agrees with WEBER and in addition is definitely against the preliminary artificial evacuation of the intestine before a barium meal examination is started (e g BAROWSKY 1951) Prior to and in connection with an examination of the normal function of an organ every unphysiologic interference is to be condemned, nor must the method of examination interfere more than is necessary with such function It would appear therefore that the small contrast meal examination is superior to the methods employed earlier and can, better than any other method, demonstrate the individual type of intestinal function

Constipation is a condition in which the bowels open infrequently and with difficulty or in which the faeces are retained (STEDMAN's Medical Dictionary 1953 and the British Medical Dictionary 1961)

Information in the literature, based on results obtained with the aid of ordinary large barium meals, indicates with only one exception that a normal large bowel empties in 48 to 72 hours KANTOR concludes from this that a longer emptying time indicates constipation It was however shown in the previous communication by the present author that the large bowel may not be completely empty until after six days in symptom free young subjects who have a regular, daily motion Only if this time is exceeded would a label of constipation therefore appear to be justified

Material Eighty five patients, with symptoms of abdominal fullness and tension with colicky pain, usually on the left side, to suggest chronic constipation, were subjected to the small contrast meal examination The series must be considered as decidedly pathologic The patients had mostly been treated with drugs over long periods, and many had been considered as suffering from



a



b

Fig 4 Small contrast meal examination in chronic constipation before operation (a) and after (b) Before operation the emptying time was 9 days Films from the 1st 3rd 5th and 7th days show slow progress of the barium meal After operation the emptying time was 4 days films from 1st and 3rd days show some accumulation tendency to persist but emptying time is normal and the patient was symptom free

various conditions, such as possible ileus Those of the early part of the series, while the method was still new, were not always followed regularly until the colon was completely empty, therefore, 65 patients remain in the series

Two hundred and seventy patients were also examined during the whole 4 year period for reasons such as vague abdominal pain, injury, post operative conditions and colitis These are only mentioned to show that the method was considered suitable for a range of indications that provided an opportunity for assembling experience of its applicability they will not be discussed in the present paper

The small contrast medium examination is in brief performed as follows The patient leads a completely normal life with no restrictions on food or drink and following breakfast in the morning 15 ml of a suspension containing 15 to 20 grams of dry barium sulphate is ingested The first film is taken the next morning and is followed by exposures at 24 hour intervals until the large intestine is completely empty The number of stools passed during the 24 hours is reported at each examination

Thirty per cent of the patients believed to have constipation had evacuated all the contrast medium within 6 days Bowel movement was infrequent however, and therefore one of the criteria of constipation was met Some of the patients were given an enema before the examination was completed because of intolerable abdominal pain, marked stagnation of the intestinal contents was evident with considerable faecal accumulation in the descending colon and sigmoid (Fig 1)

This accumulation of faeces seems to be a characteristic phenomenon in constipation and was more or less marked in all the present examinations Deep haustrations in the left colon to suggest spasticity are usually evident The haustra may be completely separated when the condition is advanced, the faecal clumps being strung out like a garland or a string of beads A typical example of a constipated bowel that emptied in 6 days although infrequently is shown in Fig 2 There is considerable accumulation of faeces in the left colon

The large bowel was empty between 7 to 12 days in the remaining 70 per cent of the present patients The progress of the intestinal contents was slow and there was a marked accumulation of faeces on the left side The barium meal at 24 hours sometimes filled only the ascending colon but occasionally the transverse colon was outlined as well Filling of the sigmoid colon or the rectum within a day was rare The accumulation of faeces usually started in the left part of the transverse colon and increased aborally Characteristic appearances with the large bowel free from contrast medium in 10 days are illustrated in Fig 3

Professor Seiro of Helsinki university has for a number of years considered that spasticity of the left part of the colon and sometimes of the small intestine may arise from hyperfunction of the sympathetic nervous system He has found that gratifying results have been obtained in chronic constipation with marked symptoms by subdiaphragmal splanchnicectomy together with high lumbar sympathectomy, first on the left side and, if necessary, followed by a similar operation on the right side These procedures are illustrated in the following two cases

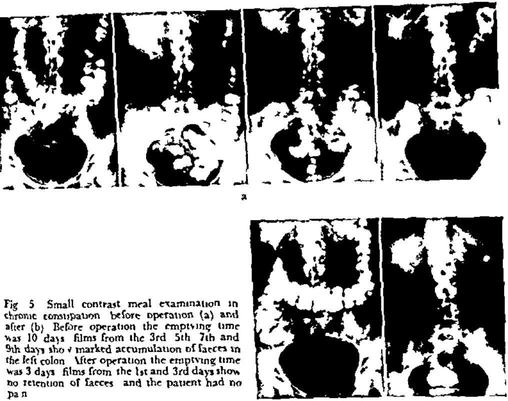
Case reports

Case 1 A man of 30 had passed stools about every three days for several years and experienced violent diffuse cramp like abdominal pain roughly three times a week often in connection with defaecation The stools consisted of hard round lumps

A small contrast meal examination was performed in January 1959 (Fig 4a) there was marked accumulation of faeces with evidence of contrast medium for up to 9 days

High lumbar sympathectomy and left splanchnicectomy (SEIRO) were performed a month later the patient was well for 6 months and the bowels functioned regularly Subsequently however the earlier symptoms recurred and the corresponding operation was performed on the right side

In November 1960 i e more than a year later the patient had no abdominal pain the bowels functioned daily and were free from contrast medium in 4 days (Fig 4b)



a

b

Fig 5 Small contrast meal examination in chronic constipation before operation (a) and after (b) Before operation the emptying time was 10 days films from the 3rd 5th 7th and 9th days show marked accumulation of faeces in the left colon After operation the emptying time was 3 days films from the 1st and 3rd days show no retention of faeces and the patient had no pain

Case 2 A woman of 40 had suffered for two years following a gallbladder operation from severe constipation with a feeling of fullness in the abdomen and occasional pain

A small contrast meal examination (Fig 5a) was made in September 1960 There was marked accumulation of contrast medium in the left part of the colon The large bowel was empty in 10 days

Left lumbar sympathectomy and left splanchnicectomy (SEIRO) were performed a month later the operation produced relief of symptoms and regular bowel function

A small contrast meal examination in November 1960 showed no accumulation of faeces in the left part of the colon and the bowel emptied in 3 days (Fig 5b)

Discussion and Conclusions

It is usually accepted that an emptying time of the large bowel exceeding 72 hours indicates constipation This limit value has been arrived at by roentgen studies performed with an ordinary contrast meal Most authors probably have not considered the definition of constipation and have therefore neglected the other essential symptom infrequent motions

The small contrast meal examination shows that the normal emptying time of a large intestine varies within wide limits and that the maximal time is

higher than has been recognized earlier. There is a growing tendency to suspect constipation when the emptying time begins to approach the top limit, 6 days. It has transpired, however, that for the proper assessment of constipation another two factors should be considered in addition to the absolute emptying time, viz. the tendency to an accumulation of faeces in the left part of the colon, and the emptying frequency.

Constipation may therefore be diagnosed if one of the following three conditions is met with: 1) if a small contrast meal examination shows contrast medium in the large bowel after more than 6 days, there should also be an accumulation of faeces in the left part of the colon, 2) if there is definite accumulation of faeces in the left part of the colon although the bowel contains no traces of the meal at 6 days or under, and 3) if the bowels open infrequently, i. e. only every 2 days or even less often.

The present series included no typical cases of so called ascending or transverse colon constipation with local stagnation of the intestinal contents in only these areas for several days. It may well be asked whether there is really any justification for such a classification. It is presumably based essentially on the physical factors of the large barium meals that used to be employed for the diagnosis of constipation. The contrast medium, if given in larger than ordinary amounts may easily stagnate in a proximal part of the large bowel while the other sections become spastic and reluctant to accept the dehydrated and consequently hard barium faeces. When the latter finally start moving they are probably projected onwards in one movement as far as the rectum, the descending colon and the sigmoid colon thus remain unfilled throughout the examination. This results in over evaluation of the tendency to stagnation in the proximal parts of the large bowel, which obviously is a secondary phenomenon.

A small contrast meal, on the other hand, contains such small quantities of barium that the intestinal function cannot be appreciably affected. It is true that often only the ascending or the ascending and transverse parts of the colon were filled with contrast medium in the present series. During the following days, however, the contrast medium moved on over varying distances aborally while more proximally the colon filled with ingested material free from contrast medium.

There were no instances of marked rectal constipation. It would appear *that the stagnation of the whole of the contrast medium in the rectum* for 2 days, during which the subject passes no motion, does not constitute dyschesia. No evidence of longer filling of the rectum was encountered in the series.

It is worth emphasizing that even in marked constipation without the passing of a motion for 2 or 3 days some daily progression of the intestinal contents occurs. An atonic intestine is presumably extremely rare, perhaps non existent. This opinion is shared by BAROWSKY and by ALMY.

The examination results reported in the present paper, supplemented with

the conclusions arrived at from small contrast meal examinations of normal subjects, suggest that the primary cause of chronic, painful constipation is increased tonus of the intestinal musculature in the left half of the large bowel and especially in the descending colon and sigmoid colon Normal and constipated intestines overlap in appearance and in consistency of the faeces in the left colon, when the emptying time approaches the top limit of the normal, i e 6 days

The combination of painful constipation and a similar condition without pain is not unusual in the same subject and the two states may alternate A variation in the neurogenic irritability of the large intestine and perhaps also in the pain threshold, is probably the main factor determining the type of constipation present at a given period

There are divergent opinions regarding the value of a contrast meal examination in constipation KAPEL (1958) stated that a number of oral contrast medium studies of the colon are necessary before it is possible to diagnose possible areas of stagnation and cure the constipation by a resection ROMANUS et coll (1962) held that a contrast meal examination of the large bowel possibly permits a differentiation between types of constipation but that the examination has no practical value The present author would subscribe to this view as regards the conventional meal The small contrast meal examination is however, quite different and offers an invaluable method of assessing colonic function In the mixture of psychic and organic functional factors that make up the complicated complex termed chronic symptomatic constipation an objective verification of intestinal function must be considered an essential part of the examination of the condition

Acknowledgement

The author s best thanks are due to Prof V Seiro for the unlimited study material placed at his disposal and the untiring interest he has shown in the performance of the examinations and the preparation of this paper

SUMMARY

Eighty five cases of chronic constipation were studied by the small contrast meal examination method Three criteria of constipation are presented if the emptying time of the large intestine exceeds 6 days if there is an accumulation of faeces in the left half of the colon and if emptying of the large bowel takes place only every 2 days or even less frequently The value of high lumbar sympathectomy and splanchnicectomy is discussed

ZUSAMMENFASSUNG

Fünfundachtzig Fälle von chronischer Verstopfung wurden mit Hilfe einer kleinen Bariumverabreichung studiert Die Aufmerksamkeit wird auf 3 Punkte konzentriert die Entleerungszeit des Dickdarms kann mehr als 6 Tage betragen eine Kotanhäufung findet im linken Dickdarm statt Entleerungen vom Mastdarm erfolgen nur jeden zweiten Tag oder sogar seltener Der Heilwert der hohen lumbalen Sympathektomie und der Splanchnicus Durchtrennung werden erörtert

RÉSUMÉ

Quatre vingt cinq cas de constipation chronique ont été étudiés par la méthode du petit repas opaque L auteur donne trois criteres de constipation le temps d évacuation du gros intestin dépasse 6 jours il y a une accumulation de matieres fécales dans la moitié gauche du colon l évacuation du gros intestin n a lieu que tous les deux jours ou meme moins souvent L auteur examine l intérêt de la sympathectomie lombaire haute et de la splanchnicotomie

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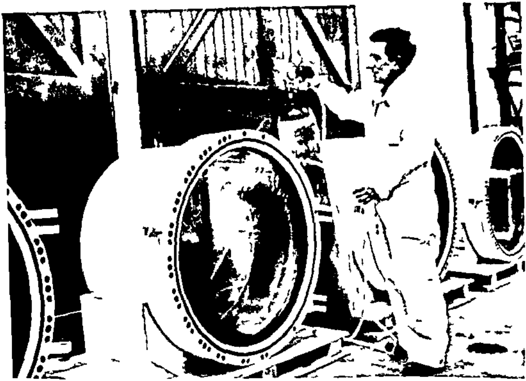
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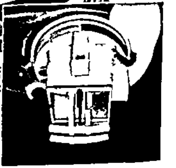
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BIOMECHANICS OF THE LUMBOSACRAL NERVE ROOTS

by

ALF BREIG and OLLE MARIONS

It has earlier been demonstrated (BREIG 1960) that when the head and spinal column are bent in different directions, the continuous tissue tract consisting of the hind brain, spinal cord, and the associated cerebral and spinal nerves change in form and tension In ventroflexion, the increase in tension is mainly a result of the lengthening of the spinal canal and the subsequent stretching of the cord which is anchored at its extremities In dorsal extension on the other hand, the spinal canal is shortened and the tissue tract slackens By taking account of this behaviour it is possible to predict the state of tension in the cord for any position of the head and spinal column

Knowing the mechanism whereby the normal deformation of and the change of tension in the tissue tract are caused by the normal lengthening and shortening of the spinal canal it can be deduced how pathologic tension is set up in the tissue tract by skeletal alterations which increase the length of the canal, and by pathologic changes in the soft tissues which alter their normal adaptability

These basic phenomena were analysed on autopsy specimens and on spinal cords exposed at neurosurgical operations

Hitherto the application of radiography in this field has been limited to a study of the influence of head posture on the configuration of the fourth ven

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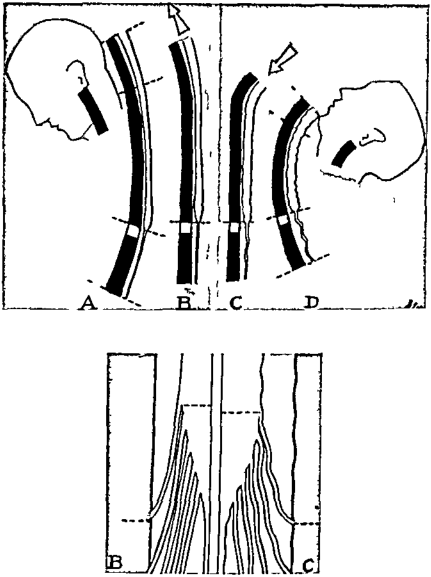


Fig 1 Diagrammatic representation of effect on the cord and lumbosacral nerve roots of bending of various sections of the spinal column

Ventroflexion of whole column (A) Elongation of cervical lumbar and thoracic sections of spinal canal in decreasing order of magnitude Dura cord and nerve roots stretch proportionally no axial displacement of cord

Ventroflexion of cervical spine alone with thoracic and lumbar column straight (B) Elongation of cervical canal and stretching of dura cord and nerve roots of cervical section this effect is transmitted to the lumbosacral nerve roots

Dorsal extension of cervical spine alone (C) Shortening of cervical canal dura cord and nerve roots slacken this effect is transmitted to the lumbosacral nerve roots

Dorsal extension of whole spinal column (D) Shortening of all sections of canal dura cord and nerve roots slacken and fold no axial displacement of the cord



Fig 2 Sacral cone and nerve roots of cauda equina stretched in ventroflexion of whole column (a) slackened and following a wave like course in dorsal extension of whole column (b)

tricle (GREITZ, and LINDGREN) On encephalograms of eleven patients at Serafimerlasarettet they found that in dorsal extension there is a definite protrusion of the tela chorioidea and chorioid plexus into the fourth ventricle Owing to the use of intratracheal anaesthesia, extreme positions of the head, which would probably have resulted in even more marked deformation, could not be produced in these patients

It has long been known that the spinal canal is lengthened in ventroflexion and shortened in dorsal extension and until recently it was thought that the dura and the cord do not vary in length and therefore move cephalad in the canal in ventroflexion and caudad in dorsal extension This would mean that in ventroflexion the sleeves of *the lumbosacral nerve roots*, which are almost parallel to the canal leave the intervertebral foramina and slide cephalad and that in dorsal extension they move caudad and re enter their foramina It was also generally accepted that a pathologic protrusion into the spinal canal or into the intervertebral foramina tends to damage the cord or the nerve roots by compression

As an aid to a more thorough understanding of the deformation of and changes in tension in the lumbosacral nerve roots, it may be in place to outline some of the basic biomechanical features of the continuous tissue tract comprising the hind brain, spinal cord and associated nerve roots

The dura is firmly anchored at its extremities at its cranial end to the posterior fossa and at its caudal end to the intervertebral foramina, by the fibrous connections of the root sleeves The tissue tract is anchored to the mesencephalon and at its caudal end where it consists of the lumbosacral nerve roots it is ultimately attached to the same fibres as the dura Since the dura and the tissue tract are thus affixed at their extremities to the skeleton and other unyielding structures the lengthening of the spinal canal accompanying ventro-

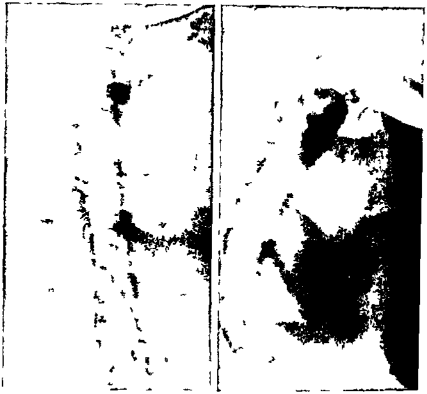


Fig 3 Air myelography of cervical cord The head and cervical spine are not bent to maximum extent owing to the use of intratracheal anaesthesia but the anteroposterior diameter of the cervical cord is nevertheless decreased in ventroflexion (a) and increased in dorsal extension (b) (Courtesy of Freidenfelt)

flexion results in stretching of the dura, the dentate ligaments and the cord, while the shortening of the canal in dorsal extension leads to their slackening

During the movement of the whole spinal column from maximum dorsal extension to maximum ventroflexion, the elastic pia is also extended, and from the erect position onwards it is subjected to tension which is transmitted fairly uniformly throughout the tissue tract from the hind brain to the lumbosacral nerve roots

The sequence of events is then briefly as follows

In *maximum ventroflexion of the whole column* both the dura and the tissue tract comprising hind brain, cord and lumbosacral nerve roots are drawn out to their optimal extent, at the same time they decrease slightly in cross sectional area (Figs 1 A and 2a) They are then under slight but definite tension, as a result of which the dura and cord can be displaced neither radially nor axially in the canal



Fig 4 To investigate the extent of shortening of the cervical cord and canal a paper strip indicator was anchored in the exposed cord (upper right) Keeping the thoracic and lumbar spine straight all the nerve roots at the level of L 4 were held in a loop of fine thread and raised by a spring balance The elevation of the nerve bundle from the lumbar canal at a tension of 20 g was read off on a centimetre scale (lower right) In slight dorsal extension of the cervical spine the nerve roots were less raised from the lumbar canal (upper left) than in more marked dorsal extension (lower left)

In *maximum dorsal extension* on the other hand, the dura and tissue tract are slackened and they increase in cross sectional area (Figs 1 D and 2b) From its smooth form in ventroflexion the dura goes into folds like an accordion and the surface of the pia and cord forms small transverse folds, a feature that is particularly distinct on the dorsal aspect of the cervical cord in which section the shortening of the canal is greatest Owing to this slackening the dura, cord and nerve roots can be moved axially and radially

Corresponding to this deformation of the cord in ventroflexion and dorsal extension the axons are stretched and slackened respectively

Dorsal extension of the cervical spine alone results in a shortening of the cervical canal and cord (Fig 3) This reduction being greater than that for all the other

canal and cord sections together, it contributes most to the general slackening of the dura and tissue tract (Fig 1 C) During this movement — involving flexion of the neck — it can be seen through the exposed cervical dura, when translucent, that the cervical cord and nerve roots become increasingly slack and hence mobile This is evident from their enhanced movement with inspiration

Ventroflexion of the cervical spine alone results in a lengthening of the cervical canal and cord This extension being greater than that for all the other canal and cord sections together, it would be largely responsible for the tension in the dura and pia (Fig 1 B) It could therefore be expected that when the cervical spine alone is ventroflexed with the upper trunk held erect, the pia would be stretched and the resulting tension would ultimately be transmitted to the sacral cone and the lumbosacral nerve roots That this in fact occurs was clearly established The deformation and change in tension observed in this process is analysed below

I Anatomic study

The effect of ventroflexion and dorsal extension of the cervical column (the rest of the column being maintained straight) on the shape of, and tension in the sacral cone and the nerve roots of the cauda equina was studied on 9 cadavers

A *Measurement of changes in tension in the cauda equina* In 2 cases the lumbar canal was exposed by laminectomy with the cadaver in the prone position on a flat surface At the level of L 4 a fine thread was passed around the nerve roots and attached to a spring balance which was then raised At a tension of 20 g the distance that the nerve bundles had been elevated from the lumbar canal was read off on a centimetre scale (Fig 4) Instead of measuring the curvature of the cervical spine, an indicator was anchored in the cervical cord by which its actual elongation and shortening could be observed directly

B *Direct observation of the deformation of* (1) the sacral cone and cauda equina laminectomy on two subjects under similar conditions to those under (A), of (2) the root sleeves and nerve roots procedure as under (A) carried out on two subjects, bilateral exposure of the intervertebral foramina as far as the spinal ganglia

C *Recording of the deformation of the sacral cone and the cauda equina by myelography* In the case of 3 subjects, the back was supported up to Th 1 by a table, the upper end of which was raised slightly so that the spinal column was inclined The cisterna cerebellomedullaris was punctured and 40 ml Urografin 45 % were injected into the subarachnoid space In each of the three subjects three exposures were made with the cervical spine in maximum ventroflexion in the erect position, and in maximum dorsal extension



a b

Fig 5 Myelography on a cadaver a) Maximum ventroflexion of cervical spine alone with thoracic and lumbar spine kept straight The lumbosacral root sleeves and nerve roots are stretched and in contact with the pedicles the nerve roots are in contact with the superior surfaces of the sleeves b) Maximum dorsal extension The root sleeves are slackened and no longer in contact with the pedicles the nerve roots are slightly wavy and not in contact with the superior surface of the sleeves

Results

The tension in the nerve roots of the cauda equina, first recorded in the erect position of the cervical spine, increased with the degree of ventroflexion The measuring system was too crude to provide exact values

From the erect position to maximum dorsal extension of the cervical spine the cauda equina could be raised further from the lumbar canal (Fig 4) This increasing relaxation was a result of the progressive shortening of the cervical canal, since the extensibility of the cord and nerve roots is constant

Only when approaching full ventroflexion was there any evidence of a deformation of, and change of tension in the sacral cone, cauda equina and the dura and root sleeves

In both the subjects used it was noted that in maximum ventroflexion the dura and root sleeves and the cord and nerve roots moved craniad for a distance of 1 to 2 mm in relation to a reference point on the caudal margin of a vertebral arch of the undisturbed thoracic spine, 6 cm cranially to the sacral cone At the same time there was evidence of an increase in tension in the dura and root sleeves and in the sacral cone and the nerve roots of the cauda equina and moreover a small but definite reduction in the cross section of the dura and the sacral cone This change is clearly seen in Fig 5, and can be followed particularly well towards the tip of the cone the decrease in cross section of the dura from Th 12 to the caudal end of the dura is also depicted

Taking as indicators one well defined point of the blood vessels on the dorsal aspect of the cord slightly cranially to the cone, and another such point 6 to 8 cm further caudally on the dorsal aspect of the filum terminale, one could see that when the cone and cauda were under tension in maximum ventroflexion of the cervical spine, the cranial point moved about 1 to 2 mm cephalad while the caudal point was displaced less than 1 mm in this direction The situation then obtained was similar to that in which a uniform rubber band, with one end fixed, is stretched, then, although equal sections are elongated by the same amount, points near the fixed point move smaller distances from it than more remote points The corresponding process in the dura and spinal cord was observed, but only for a fairly high degree of ventroflexion of the cervical spine, when the cervical cord and dura are under tension In the reverse movement of the cervical spine, from maximum ventroflexion towards extension, this tension in the pia and cord and the nerve roots disappeared long before the spine had reached the erect position The sequence of events accompanying this relaxation phase, during which the indicator points moved caudad, could not be followed as easily with the unaided eye as the events accompanying the tension phase

Since the maximum stretching of the dura and cord results from the elongation of the whole spinal canal, the lengthening of the cervical canal alone will result in a similar, though smaller tension Whereas the elongation of the whole column produced a corresponding extension of each section of the canal, dura and cord, the elongation of the cervical spine alone resulted in the transmission of the tension set up in the cervical cord to the stationary thoracic and lumbar tract

The extremely small axial displacement cephalad of the lumbar section of the dura and of the sacral cone and nerve roots of the cauda equina was consequently a result of incomplete unfolding — that is, the unfolding of only the upper part of the dura and tissue tract

In dorsal extension there is a slight relaxation of the dura, root sleeves and nerve roots of the lumbosacral region, similar to that in the cervical region During this relaxation the root sleeves move away from the pedicles, and the nerve roots from the superior surface of the sleeves (Fig 5b) In ventroflexion, the dura, root sleeves and nerve roots are stretched, the sleeves come in contact with the pedicles and the nerve roots in contact with the superior surface of the sleeves (Fig 5a) This stretching mechanism is apparently engaged to the maximum only in full ventroflexion of the whole vertebral column, that is, when unfolding is complete

In the extension of the cervical dura and cord by ventroflexion of the cervical spine alone, a small pull was seen to be transmitted to the thoracic and lumbar sections of the dura and cord, resulting in their slight cranialward displacement in the canal On the other hand, in ventroflexion of the whole column, when the thoracic and lumbar parts of the canal were also elongated, the thoracic



Fig 6 Extreme positions of head and cervical column during contrast myelography of the lumbosacral nerve roots

and lumbar sections of the dura and cord moved back caudalward to the same extent There was therefore a proportional elongation of the canal, the dura and the cord in all sections of the column

In dorsal extension of the cervical spine alone the sacral cone and the nerve roots of the cauda equina followed a gently wavy course (slackened) (Fig 5b) whereas in ventroflexion they were straight (stretched) (Fig 5a) In spite of this difference there was no evident displacement of the cone in relation to the margins of the vertebral bodies

II Myelographic examination

In myelography it has been the practice in our department since late in 1960 to supplement the usual exposures of the lumbar canal with four special films

In order to obtain comparable roentgenograms, the thoracic and lumbar parts of the spine were held in a fixed straight position for all exposures with the patient lying on the side on which a herniated disc was suspected Exposures of the lumbar spine were made in two extreme positions with the head bent forwards the chin drawn in and the cervical spine ventroflexed, and with the head bent backwards (Fig 6) In each of these extreme positions of the cervical spine exposures were made with the roentgen beam perpendicular to the

Table

Decreasing angle of the lumbosacral nerve roots to the horizontal margins of the vertebrae owing to dorsal extension as observed in 74 cases

	Lateral projection	Oblique projection
Not visible	11	11
Just visible	15	21
Obvious	21	27
Marked	12	15
Totals	59	74

spinal column, and with the patient lying on the side on which a herniated disc was suspected, and then in semiprone position, i e with the frontal plane at 45° to the table

In practically all cases the indication for myelography was hernia of an intervertebral disc, or suspected relapse, in cases where the neurologic signs alone were insufficient either for making a diagnosis or for ascertaining the level of the hernia

Premedication consisted in intramuscular administration of 0 10 g fenemal and shortly before the examination, 50 mg ephedrin For the spinal anaesthesia xylocaine 5 % (heavy) was given in doses of 0 4 to 0 8 ml The contrast medium was U Leo 20 % (sodium monoiodomethansulphonase), of which 10 to 12 ml were injected except in the few cases in which the subarachnoid space was known to be particularly large In these cases the dose was increased to 15 ml The roentgenograms were obtained in the usual manner, with a horizontal beam and the subject in lateral position, with different degrees of rotation

An examination of the supplementary roentgenograms showed that the following features could be recognized, in decreasing order of accuracy

1 Change in inclination of the nerve roots, the chosen reference lines were the horizontal margins of the vertebral bodies, the angle described is that made by a lumbar or sacral nerve root to these lines,

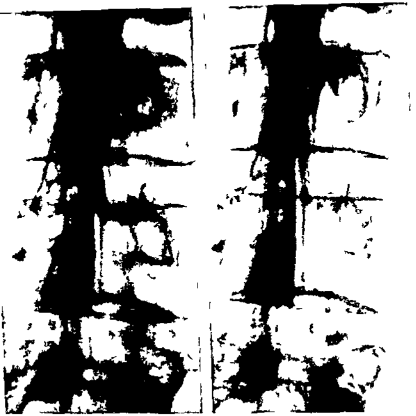
2 Deformation of the root sleeves in normal cases,

3 Deformation of the root sleeves and the course of the nerve roots at the level of the hernia, use was made only of those roentgenograms in which the correspondence of the skeletal exposures in ventroflexion and dorsal extension was satisfactory, all the roentgenograms in which a more than slight rotation of the lumbar spine was recognizable were rejected

Results

Original material 103 patients with the specified supplementary films

The aforementioned requirements regarding the technical quality of the roentgenograms and correspondence between the pairs, and between the films of each pair, were satisfied in 57 cases with 2 film pairs in lateral projection and



a b

Fig 7 In dorsal extension of the cervical spine (a) the nerve roots form a smaller angle with the margins of the vertebral bodies than in ventroflexion (b) The nerves are respectively slackened and stretched

oblique projection in 17 cases with pairs in oblique projection, and in 2 cases with pairs in lateral projection The better evaluation of the films in oblique projection was largely due to the fact that when the subject was turned into the semiprone position a greater number of roots in a larger section of the lumbar spine were visible

In all cases the only difference between the exposures in ventroflexion and dorsal extension was that in the former position the angle between the nerve root and the vertebral margin was larger than in the latter position Consequently only the figures concerning the difference in shape of the roots in dorsal extension are presented in the Table the differences in shape have been graded as not visible just visible obvious and marked

In 48 cases of lateral projection and in 63 of oblique the angle of the lumbosacral nerve roots to the margins decreased when the cervical spine was moved to maximum dorsal extension (Fig 7a) In a few cases this change was obvious

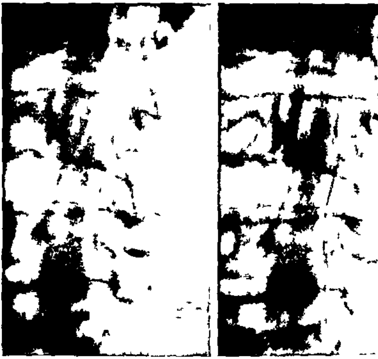


Fig 8 Herniated disc at level of L4—L5 a) Dorsal extension of cervical spine the involved nerve root is slack b) Ventroflexion the involved nerve root is stretched over the protrusion

in only one or two roots, and then usually in the lateral projection A decrease in the angle was to be seen more often on the more cranially situated lumbar roots just below the sacral cone than on the more caudal roots

The deformation of the extremities of the root sleeves was consistently small or extremely small and not constant However, the contrast filling at the tip of the root sleeve in dorsal extension was slightly better in 13 cases of lateral projection and in 17 cases of oblique projection In ventroflexion, on the other hand, the extremities of the root sleeves were filled in 2 cases of lateral projection and in one case of oblique projection In 2 cases the root sleeves adjacent to the caudal curvature of the vertebral pedicle were filled in dorsal extension while in the corresponding roentgenograms in ventroflexion there was no evident filling Two roots running close together (anterior and posterior roots) were fairly often visible either for the greater part of their course or only near their entry into their common sleeve (Fig 9) This was seen more clearly and more often in dorsal extension

In 9 cases a better filling of the root sleeves was noted in dorsal extension at the level of, and above, the hernia (Fig 8a), and in one case the filling was better in ventroflexion In 3 cases the bulging of the hernia into the contrast filled root sleeves was more distinct in dorsal extension and in one case more

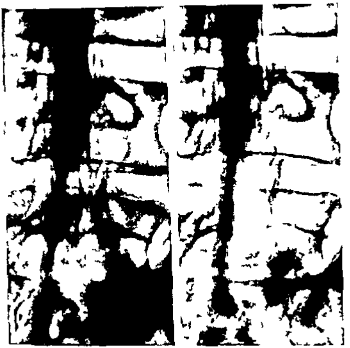


Fig 9 Herniated disc at level of L5—S1 The disc protrudes deeper into the subarachnoid space in dorsal extension of the cervical spine (left) than in ventroflexion (right) where the bulge is shallower



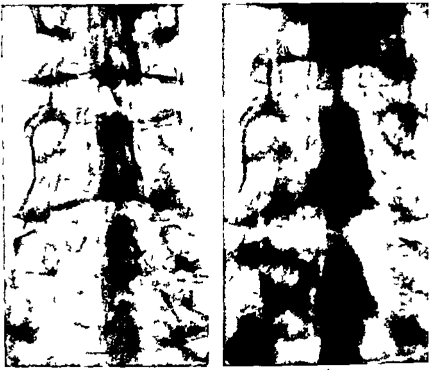
Fig 10 Obliquely coursing nerve roots

distinct in ventroflexion In several cases the protrusion into the root sleeve in ventroflexion was distinctly broader and more shallow in both projections and *in dorsal extension narrower and deeper In these cases, moreover, the curvature* of the affected nerve root was distinctly smaller in ventroflexion (Fig 9b) In 8 cases there was no definite change in the appearance of the root sleeves at the level of the hernia

Discussion

As earlier mentioned when the routine exposures were completed the patient was shown the required head and neck positions for the supplementary special exposures The absence in some cases of any apparent difference in the course of the lumbosacral nerve roots in ventroflexion and dorsal extension may have been due to the fact that not every patient could carry out these movements identically and in the required manner owing to physical factors such as pain or fatigue or to slackness of dura and cord in advanced disc degeneration

All the roentgenograms on which there was the slightest sign of rotation were excluded from the examination, since it was evident from a comparison with the other exposures of the series that rotation might result in a considerable error in projection which could prejudice any evaluation of the relevant changes On



a b

Fig 11 a) Dorsal extension of the whole vertebral column The nerve roots are slack and wavy b) Ventroflexion The lumbosacral nerve roots are stretched

the other hand, seven films on which some degree of kyphosis of the lumbar spine was evident in ventroflexion of the cervical spine were included Most of the other patients held the lumbar column straight when performing the same movements

The findings establish beyond doubt that in most cases ventroflexion of the cervical spine resulted in stretching of the lumbosacral nerve roots, whereas in dorsal extension they were relaxed and displayed a gently wavy course Since there was no evidence in any of the films to indicate the opposite tendency, it may be inferred that the observed features represent a regular phenomenon This observation confirms in essence those made on autopsy specimens In the earlier investigation it was found that the lumbosacral nerve roots were slackened in dorsal extension and stretched in ventroflexion of the whole column, but it could not be established whether there was slackening and stretching when the cervical spine alone was flexed and extended No mention of this phenomenon could be found in the relevant literature (WELLAUER 1961), though ARNELL (1948) in some cases observed the wave like course of the nerve roots

In spinal fluid the nerve roots are practically weightless (BREIG 1960) The axons in the roots, like those in the cord, presumably follow a spiral course

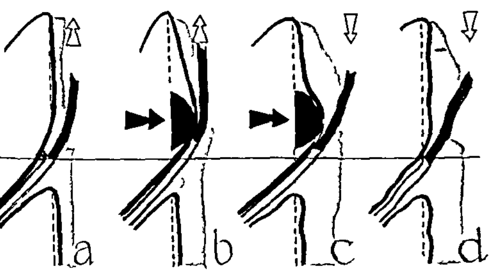


Fig 12 Deformation of and change in tension in a nerve root in the section between the hernia and site of attachment of the root in the sleeve *White arrows* Forces induced normally in extreme positions of the cervical spine *Black arrows* Pathologic forces induced by protruding disc The part of the nerve root reproduced in white is normally situated within the root sleeve and ends at the horizontal reference line a) Ventroflexion of the cervical spine Dura, root sleeve and nerve root are under slight tension b) The protruding disc displaces the dura and adjacent nerve root towards the canal Since the nerve root is attached to the arachnoidea by fibres it is drawn out to the same extent as the dura and arachnoidea This stretching of the nerve root is indicated by the extension of the white segment of the nerve root above the reference line c) Dorsal extension of the cervical spine The dura root sleeve and nerve root are slightly slackened but there is still tension in the root owing to the protrusion the white segment of the nerve root is still above the reference line d) Dorsal extension of the cervical spine Dura, root sleeve and nerve root are slightly slackened

The wavy course would then be favoured by two factors As seen in Fig 10, it can happen that the nerve roots cross one another

In dorsal extension, the root sleeves were often slightly better filled than in ventroflexion but the difference was never large On a few of the roentgenograms it could be seen that in ventroflexion the root sleeves were drawn out straight and pulled against the vertebral pedicles whereas in dorsal extension they were relaxed and moved away from the pedicles This may explain the poorer filling of the root sleeves in this region, often noted in ventroflexion and bears out the observations on anatomic specimens and at operation It might be expected that these apparently small differences in filling would be less noticeable when part of the subarachnoid space is deformed by a hernia but in fact, the contrary was sometimes the case Hence the radiologic diagnosis of herniated discs would seem not to be facilitated by ventroflexion or dorsal extension of the cervical spine When however the whole column was bent into the extreme positions the difference in the contour of the dura and the course of the nerve root was greater (Fig 11) Advantage may be taken of this fact to improve the radiographic demonstration of extra and intradural pathologic changes

The nerve roots emerging further caudally from the dural sac — that is, in the usual area of hernia of the lower lumbar and upper sacral regions — usually did not display a marked change in their course during elongation or shortening of the cervical canal, as noted above This, however, does not mean that the tension in these roots is changed less than in those situated further cranially (see above)

A nerve root displaced mediad by a discal hernia and distinctly stretched in the section between the hernia and its site of attachment in the root sleeve is shown in Fig 8 In this section neither ventroflexion nor dorsal extension produced any appreciable deformation of or change in the course of this nerve root but, just above the hernia, dorsal extension of the cervical spine was accompanied by a marked waviness of this root This relaxation of the nerve root in this region obviously had no influence on its local stretching in the section between the discal hernia and the attachment of the root in the intervertebral foramen In two or three other cases of hernia, on the other hand, the curvature of such a nerve root decreased slightly in ventroflexion and increased slightly in dorsal extension This suggests that even in this section the nerve roots may to some extent be stretched and relaxed during these movements

Pathologic disturbance of the biomechanics in disc hernia These findings throw new light on the mechanical action of a protrusion on the nerve root, and provide convincing evidence that the root is not damaged by compression, as is generally considered to be the case

To understand how the impairment of the nerve root is produced by a disc protruding into the spinal canal, especially near the entrance of the intervertebral foramen, some basic anatomic details must be kept in mind The root sleeves emerge from the lateral and ventral aspects of the dura and are attached by connective tissue fibres to the bone within the intervertebral foramina and to the ligaments distal to the ganglia (FRYKHOLM) In both cervical and lumbar regions, the nerve roots pass freely through the fluidfilled subarachnoid space of the dural sac and root sleeves In the subarachnoid space of the root pouch, the space between the arachnoidea and the surface of the nerve roots is bridged by fine fibres Within the sleeves the distance between the arachnoidea and the pia is short and the bridging fibres may be quite dense

The local pathologic deformation of the dura and nerve root produced by a herniated disc must be considered together with the normal deformation of the whole dura and the nerve roots in movements of the spine Such a pathologic protrusion almost invariably stretches the dura and the arachnoidea within the section between two (or four) cranially and caudally anchored root sleeves Local tension can be set up in the dura by a protrusion from the lateral as well as the ventral direction, and, of course, intermediately In ventroflexion this local stretching is superimposed on the extension of the whole dura to produce a pathologic stretching which is transmitted far craniad and caudad In

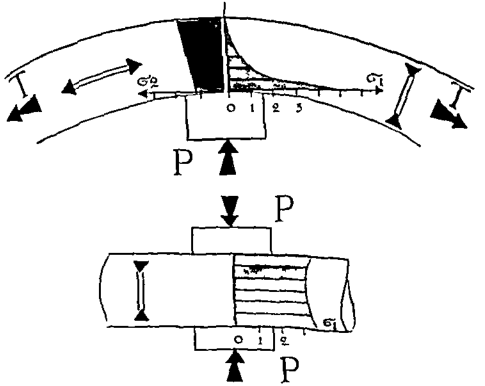


Fig 13 Pressure (geometrically determined) P tension T tension set up by pressure σ tension set up by traction σ direction of pressure (σ or P) ⟼ direction of tension (σ or T) ⟷ rigid surface supporting the nerve root shown by white rectangles

Lower diagram In this system representing a model of a pinched or squeezed nerve root the bilateral compression sets up a uni axial state of pressure (or tension) acting perpendicular to the axis

Upper diagram In this system representing a model of a nerve root stretched over a protrusion there is a multi axial state of tension The main components are σ acting perpendicular to the axis and σ acting axially At each point the tension is determined by the three components σ, σ_{II} and the angle α. σ is a maximum at the surface of contact and diminishes rapidly towards the diametrically opposite surface of the nerve root where it is zero σ increases towards this surface σ_I compared with σ_{II} is practically negligible

maximum dorsal extension the full slackening of the dura slightly reduces the tension within the section that is stretched by the protrusion but some irreversible local tension will remain

This tension in the dura acts first on the nerve root entering the dural pouch and sleeve near the protrusion The root is thereby displaced towards the lumen of the subarachnoid space and since it must pass over the protrusion it will be stretched like a string over the bridge of a violin (Fig 19) This stretching may be powerful enough to impair the root function

In ventroflexion of the cervical spine the proximal section of the affected nerve root and the section caudally to the protrusion are stretched though not



Fig 14 The Kifa Back Support produces immobilization and lordosis of the lumbar spine and hence slackening of the lumbosacral nerve roots Since it can be placed at different levels the support is suitable for all curvatures The patient can judge the correct position from the relief obtained It may be used with a foam rubber padding for emergency treatment of compression fractures of the lower thoracic and upper lumbar spine for periods of several weeks

to the maximum extent Dorsal extension of the cervical spine will lead to slackening of the nerve root so that it will move away from the disc, but the section distal to the hernia will still be under some tension, as its straight course indicates The reason for this is that, as noted above, in the region of the root pouch and sleeve the root is fixed to the arachnoidea — and dura — by bridging fibres, so that when the dura is displaced towards the lumbar canal a pathologic tension in the dural sleeve and the arachnoidea is transmitted to the nerve root within the sleeve Hence, so long as the protrusion exists the tension within the dura and the root sleeve will be accompanied by permanent tension in the nerve root Moreover, the pathologic stretching of the root will soon lead to irritation, inflammation and fibrotic processes, as a result of which the nerve root will adhere to its root sleeve and the extent to which it might yield would be still further restricted

Anatomical considerations moreover indicate that there is no true compression of the lumbosacral nerve roots when they are stretched by a protrusion Except in the case of traumatic compression of the roots between two pieces of bone, the anatomical and mechanical conditions that obtain in compression are more likely to exist within the intervertebral foramina The mechanical effect of compression of the roots and cord is quite different from that of stretching, for whereas the former gives rise to a stress acting at right angles to the root and cord, and is uniform throughout them, stretching of the root and cord over a protrusion induces an axial tension in them, which increases towards the diametrically opposite surface (Fig 13)

The surface of the protrusion on which the root and cord bear when stretched over it exerts a reactive force This is greatest at the level of contact and de

creases rapidly with distance therefrom (approximately by the third power) in the direction of the opposite surface of the root and cord, where it is zero The more prominent the protrusion is the greater will be this contact pressure The larger the area of contact between the protrusion and the root or cord the smaller will be the pressure on it

From the aspect of conductivity of the nerve root and cord it is of major practical significance to ascertain whether it has been damaged by compression or by tension McVeigh has demonstrated that the forces induced by compression of the cord (or nerve root) tend to produce an axial displacement of the cord substance and this invariably leads to irreversible damage Pathologic tension, on the other hand, is to some extent better tolerated, probably because the cord and roots are normally under tension in ventroflexion It is known that symptoms elicited by such tension disappear soon after the protrusion has been removed Surprisingly often the loss of function is reversible even in cases where the tension has persisted over a period of months, or even years This seems to indicate that the metabolism of the ganglion cells and the axons remains normal during the state of tension Whether chronic hypoxia can account for the impairment of conductivity is open to question, since hypoxia would cause irreversible damage

In view of this mechanical action of the herniated lumbar disc on the individual lumbar or sacral nerves the concept of a compression of these nerves in such cases is clearly inappropriate The process involved is rather a deformation of these nerves by the herniated disc originating in a pathologic increase in tension

It was at first uncertain whether the deformation of and change in tension in, the relatively narrow lumbosacral nerve roots expected on theoretical grounds could be reproduced in roentgenograms with the necessary precision However, in spite of the relatively small yield of only about 60 per cent of usable films the results exceeded expectations and it is evident that myelography with water soluble contrast media is an excellent method for studying the mechanical behaviour of these nerves

The results suggest that the Hyndman sign, in which patients with hernia of a lumbar disc or protrusion, experience exacerbations of pain on bending the head forwards or to the side may be ascribed to the resulting increase in tension in the lumbosacral nerve roots The mechanism underlying the injury and the cause of the neurologic symptoms may be sought in an increase in the tension of the dura and nerve roots resulting from pathologic protrusion into the lumbar canal Brachiogenic sciatica (Tornildsen) is also adequately explained on this basis Conversely the therapeutic effect obtained by placing a bolster under the back of the neck, and backward bending of the head, together with a flat or, better, a vaulted support for the lumbar spine (Fig 14) may be ascribed to the partial relaxation of the nerve roots as well as of the dura and ligaments

This investigation was supported by a grant from Fonden for Framjande av Svensk Neurokirurgi

SUMMARY

Myelography with ventroflexion and dorsal extension of the cervical spine was performed in 103 cases of probable lumbosacral disc protrusions The lumbosacral nerve roots were stretched when the cervical spine was flexed and were slackened with a slightly wavy course when it was extended the protrusion into the dura being shallower in the former manoeuvre than in the latter The increased tension in the roots may account for the neurologic signs encountered in disc protrusions

ZUSAMMENFASSUNG

Myelographie mit Ventroflexion und Dorsalextension der Halswirbelsaule wurde in 103 Fallen mit Verdacht auf Bandscheibenprotrusionen im Bereich der Lendenwirbelsaule vorgenommen Die lumbosakralen Nervenwurzeln zeigten Streckung wenn die Halswirbelsaule nach vorne gebeugt wurde und Entspannung und Schlangelung wenn die Halswirbelsaule nach hinten gebeugt wurde Die Vorwolbung der Diskushernien gegen die Dura war geringer bei Ventroflexion Die starkere Spannung der Nervenwurzeln durfte der Grund sein weshalb neurologische Erscheinungen bei Bandscheibenprotrusionen auftreten

RÉSUMÉ

Au cours de 103 myélographies avec moyen de contraste dans des cas suspects de hernie discale le rachis cervical a été mis en flexion ventrale et en extension dorsale le rachis dorsal et lombaire restant en rectitude Les racines des nerfs lombo-sacrés sont étirées quand le rachis cervical est fléchi et se détendent et ont un trajet flexueux quand il est en extension la saillie de la hernie sous la dure mere est moindre en flexion qu en extension L augmentation de la tension des racines peut expliquer les symptomes neurologiques constatés dans les protrusions discales

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OBLITERATIVE ARTERIAL DISEASE OF THE LOWER LIMBS STUDIED BY MEANS OF REPEATED FEMORAL ARTERIOGRAPHY

An attempt to evaluate the effect of long term anticoagulant therapy

by

C TILLGREN, S STÉNSON and F LUND

An account is given in the present work of repeated femoral arteriography as a means of following up the development of obliterative disease in the femoral artery and its main branches

LINDBOM (1950) gave a detailed description of the appearance of stenoses and occlusions on arteriographic examination, and compared these findings with postmortem studies He emphasized that obliterative changes are mainly located where the arteries divide and in other parts of the vessels exposed to trauma e g in Hunter s canal, which is surrounded by tense tissue and in the popliteal artery, which is exposed to frequent bending and stretching

Exhaustive accounts of femoral arteriographic techniques and findings were recently given by HASSE (1959) and by MARGULIS & MURPHY (1961) The works of these authors also contain extensive bibliographies

Long term therapy with anticoagulants was given during the last decade to an increasing number of patients with obliterative arterial disease The aim of the treatment was to counteract thrombus formation, which often exerts a

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deleterious effect on the blood supply. Total occlusion of the lumen of the coronary arteries (BJERKELUND) and other vessels of the same size may often occur solely as a result of atheromatous plaques. There is little ground in such patients for expecting anticoagulants to produce any beneficial effects. Total occlusions of the femoral and popliteal arteries are almost invariably caused by thrombus formation on diseased intima. Patients with arterial obliterations in the lower limbs may consequently be expected to benefit by antithrombotic therapy.

The femoral artery and its main branches is an area especially accessible to arteriography, and by means of repeated arteriographies it is possible accurately to follow the anatomic development of obliterative arterial disease.

LUND, in 1956 and later, reported encouraging preliminary results using this method in investigations on the effect of long term anticoagulant therapy in peripheral arterial disease. The present study is a continuation of this work.

Indications for femoral arteriography. Patients with symptoms and signs of circulatory insufficiency in the lower limbs were subjected to femoral arteriography mainly to ascertain whether a reconstructive operation on the vessels was possible. Those in poor general condition, due to cardiosclerosis or other severe disease, were excluded from arteriography.

If an aorto iliac stenosis was considered probable on account of walking pains localized in the buttock or thigh, weak femoral pulses or a systolic murmur in the groin, aortography was planned either by catheter from the contra lateral groin or by direct puncture of the abdominal aorta. However, regard was given to the greater risk of complications after these examinations than after direct puncture of the femoral artery (see below).

Repeated arteriography was regarded as indicated for the control of both surgical and medical treatment. Arteriography was usually repeated only every other year when the patients were treated medically.

Technique. The patients received 25 to 50 mg Lergigan© (promethazine hydrochloride) intramuscularly and 0.5 to 1 ml pethidine hydrochloride one hour before the roentgen examination. Ten millilitres Xylocaine© 0.5 to 1% (lidocaine hydrochloride, lignocaine Brit. Ph.) were administered as a local anaesthetic. A Sebrecht No. 150 cannula was introduced into the femoral artery in a cranial direction and just distal to the inguinal ligament, and 30 ml Urografin 60% (methylglucamine diatrizoate) were injected in about 4 seconds. As allergic reactions due to Urografin are very rare, no routine test doses have been given in recent years.

GIDLUND's one plane roll film changer with 30 × 80 cm films has been employed since 1955. Only anteroposterior projections were used. FFD 150 cm. A copper wedge filter was applied in order to compensate for a variation in absorption in the proximal and distal parts of the limb.

The exposures were started when 10 ml of the contrast medium had been injected The exposure programme was carried out for 13 seconds with one exposure every second for 4 seconds, followed by one exposure every third second for 9 seconds These times were generally sufficient completely to demonstrate the arteries from the inguinal ligament to the proximal part of the calf even in patients with retarded blood flow

The cannula was removed and local compression was exerted for at least 10 minutes on completion of the examination The patients were often kept under observation in hospital during the night after the examination but were some times allowed to go home two hours after the examination

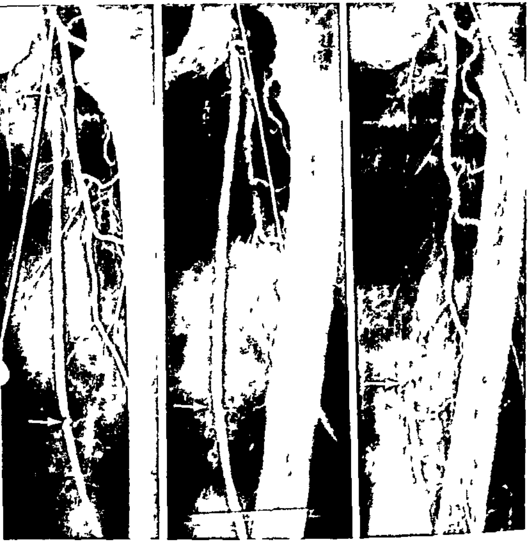
The prothrombin value in patients who were treated with anticoagulants was kept at the upper therapeutic limit on the day that arteriography was performed in order to diminish the risk of haemorrhage from the site of the puncture in the femoral artery (BELLMAN et coll) When Owren s prothrombin proconvertin or thrombotest method was used, the value was held at 25 to 30 per cent If Quick Lehmann s one stage method (microprothrombin index) was applied this index was maintained at about 60 The anticoagulant dose was when necessary slightly reduced during the week before the examination, or 3 to 15 mg of Konakion® (vitamine K_1) were given per os on the day before the examination

Material The present material was collected mainly from the roentgen departments of Sodersjukhuset, but also from those of St Eriks and St Goran s hospitals in Stockholm The arteriographies were performed during the period 1945—1961 the majority between 1955—1960 When arteriography of the lower limbs had been performed two or more times the clinical data were investigated Special attention was paid to obtaining information about the type of symptoms and the age of the patients at the onset of symptoms, as well as the kind of therapy applied, with special reference to reconstructive operations and anticoagulant treatment

One hundred and twenty five patients in all were collected Fifty one patients were excluded 2 because of normal findings in the femoropopliteal region 10 by reason of inadequate film quality 27 because of vascular operation and 12 because of unknown intensity of the anticoagulant therapy or interrupted anti coagulant therapy during the observation period

The remaining 74 patients consisted of 66 men and 8 women Most of the patients were regarded as being arteriosclerotics Four men were diabetics only two were receiving insulin treatment Buerger s disease or non specific arteritis was considered probable in 4 men, biopsy was performed only in one and confirmed the diagnosis of Buerger s disease

Complications in connection with arteriography Very few complications occurred in connection with femoral arteriography and none was fatal No allergic



a b c

Fig 1 Case 16 Female born 1897 Onset of claudication 1950 a) 20 8 1954 contrast medium defect at → in Hunter s canal b) 9 3 1956 defect not visible c) 20 8 1959 total occlusion of the superficial femoral artery extending from the origin of the deep femoral artery to the site where the initial lesion appeared in 1954

reactions were observed after the administration of Urografin®, which has been used at Roentgen Department I, Sodersjukhuset, since 1954

Small haematomas in the groin were common Larger haematomas sometimes occurred when the cannula slipped through the posterior wall of the artery, or when the artery had to be punctured several times in order to obtain a satisfactory position for the cannula As a rule, haemorrhages distal to the

inguinal ligament were easily controlled by compression against the underlying skeletal parts, and did not cause the patients much discomfort. One of the patients, however, who was erroneously punctured too far cranially, i.e. in the external iliac artery, developed a retroperitoneal haematoma that caused severe pain for some days after the examination; such a retroperitoneal haemorrhage cannot be arrested by compression. Surgical intervention became necessary in another patient, not included in this investigation, for the arrest of the haemorrhage and evacuation of the haematoma.

An arteriosclerotic plaque may become detached when arterial puncture is performed and may be carried by the blood stream as an embolus (CRAWFORD et coll.); this did not occur, however, in the present material.

There may be risk of intimal damage if the blood flow is retarded as the contact time between the hypertonic contrast medium and the intima is extended. MARCULIS & MURPHY observed an extension of an arterial thrombus when contrast medium was injected distal to an occlusion in the external iliac artery. Growth in proximal direction of a total occlusion of the femoral artery occurred in connection with arteriography in one of our patients. It was, however, impossible to ascertain whether the main cause of this complication was due to trauma to the wall of the vessel as a result of puncture, due to the contrast medium in itself, or to the decrease in the anticoagulant dose during the week before the examination.

The pain felt in connection with the injection of the contrast medium was usually of short duration. A considerable fall in the peripheral blood pressure occurred only in a few patients; this was interpreted as being due to shock caused by pain. Arteriography may consequently involve increased risk for patients with impaired cerebral and coronary circulation.

Only a few patients in the present material were subjected to aortography; no complications occurred. Sequelae in connection with aortography may prove serious, as has been pointed out e.g. by CRAWFORD et coll. Renal damage, intramural haemorrhage and fall in blood pressure, are not unusual, especially in arteriosclerotic patients.

Interpretation of arteriographic examinations

It is desirable that the whole lumen of the vessel should be filled with contrast medium which moves in a peripheral direction as an embolus (GREITZ). Stenoses and total occlusions consequently appear as protrusions and interruptions in the contrast column. The distinctness of these obliterative changes may vary, however, depending on the following factors: (1) the quantity and concentration of the contrast medium injected and the rapidity of the injection, (2) the blood flow through the extremity, and (3) the exposure technique.

If the injection is slow, the contrast medium may fill only the dependent part of the vessels (layer formation). Intimal proliferations in part of a vessel

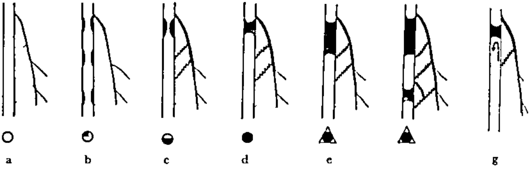


Fig 2 Classification of the arteriographic findings The differently shaded circles and the triangle simplify the findings in the following figures a) Normal artery b) Group I Plaques that moderately narrow the lumen no collateral vessels visible c) Group II Plaques that narrow the lumen considerably collateral vessels visible d) Group III Total occlusion of lumen collateral vessels visible e) Appositional growth of total occlusion f) Development of another total occlusion separate from the original one g) Retrograde contrast filling at the distal end of the occlusion

that is not filled with contrast medium may therefore escape discovery Even if the contrast filling of the lumen is complete, however, changes in the wall may appear more or less marked if the projection is altered

It often appeared in the present material that the non occluding intimal proliferations had been propagated between two arteriographies The opposite is shown in Fig 1, where an intimal proliferation evident in 1954 (Fig 1a) seemed to have disappeared in 1956 (Fig 1b) The cause of this apparent disappearance was probably a change in the exposure technique and projection On arteriography performed in 1959 (Fig 1c) total occlusion, extending from the origin of the deep femoral artery to the site where the intimal lesion was seen in 1954, was disclosed

A more exact idea of the intimal proliferations and the degree of stenosis may be obtained by roentgenography in two planes If an adequate evaluation of variations in the intimal lesions is desired, these two views, as well as a standardization both of the injection technique and the positioning of the extremity, are necessary

Classification of the obliterative lesions appearing in the films

The contrast medium in the present material was usually injected manually and only one projection was used It was therefore impossible to classify the stenoses visible in the roentgen films by the cross sectional area of the artery

Groups I and II Patients who had different degrees of stenosis but no visible collateral vessels were referred to as group I (Fig 2b) Tortuous, dilated branches that allowed the blood to by pass a stenosed or occluded section of an artery were defined as collateral vessels



a b

Fig 3 Case 77 Male born 1904 Onset of claudication in 1955 a) 30 5 1956 arteriography group I atheromatous plaques only b) 4 4 1960 arteriography group III total occlusion developed

The appearance of collateral vessels was regarded as a reliable sign of a high degree of stenosis of the arterial lumen and such patients were classified as group II (Fig 2c)

Group III Total occlusion of the lumen (group III) generally could be readily distinguished from stenoses It was however sometimes extremely difficult to decide whether the occlusion was total or not Some of the films in two patients indicated a slight flow of contrast medium through a vessel in which previous arteriography had shown total occlusion Recanalization might have taken place, but changes in exposure technique and possibly some retrograde contrast filling might have explained the variation in the findings It was naturally of no clinical importance whether an extreme stenosis or a total occlusion was present but it is of great theoretical interest to know if arterial recanalization can occur spontaneously or as a result of treatment (Hasse)

Retrograde flow An occlusion may appear longer than it really is if the exposure programme is terminated too soon The contrast medium may flow at the distal end of the occlusion in a retrograde direction (Fig 2g) through the collateral pathways The blood flow may be more rapid through the collateral vessels than through the stenotic area when there is a high degree of stenosis and thus cause retrograde filling of the distal lumen

Definition of the propagation of obliterative changes in the roentgen films

The present material of roentgen films did not permit a reliable evaluation of variations in the degree of non occluding lesions Propagation of the obliterative changes was therefore said to have occurred only in cases of



Fig 4 Case 40 Male born 1913 Onset of claudication in 1954 a) 24 11 1954 total occlusion of popliteal artery b) 4 10 1955 appositional growth of total occlusion in proximal direction c) 25 8 1958 total occlusion of the superficial femoral artery

1 Development of total occlusion (Fig 3b) in arteries that previously had only stenosing wall changes of varying degree (Fig 3a),

2 Appositional growth (Fig 4b) of a total occlusion or development of new total occlusions proximal or distal to the original one (Fig 4c)

No attempt has been made to correlate the roentgenologic findings to the clinical course A clinical deterioration is probably always connected with an arteriographic propagation, whereas an increase in the roentgenologic signs may occur not infrequently in spite of an unchanged or even improved clinical condition such improvement is due to the development of collateral vessels compensating for the loss of blood flow through the obliterated artery The clinical aspects will be considered in a later paper

Definition of the observation period and tendency to propagation

An observation period was defined as the time between two arteriographies of the same limb

When no striking propagation occurred between more than two consecutive

Table 1

Arteriographic state in 41 patients examined twice in both limbs

	In neither of limbs	Total occlusion One limb	Both limbs
First examination	10	18	13
Final examination	7	17	17

Table 2

Propagation tendency in different age groups i e number of patients per 100 observation months with development of total occlusions or appositional growth of existent total occlusions (total occlusions originally more than 27 cm in length were excluded)

	Observation periods		Observation time (months)			Propagation tendency
Age at beginning	Total number	Propagation occurred in	Total	Mean	Range	
60—	35	6	1 122	32 1	2— 98	0 53
50—59	69	24	2 747	39 9	2—131	0 87
—49	16	9	479	29 9	2— 62	1 88
Total	120	39	4 348	36 2	2—131	0 90

arteriographies the whole time between the first and the last examination without signs of increase was reported as one observation period

When the arteriographic conditions were unchanged between two examinations but propagation was shown to have occurred in the subsequent arteriogram two observation periods were reported one with an unchanged condition and the other showing an increase

Finally if propagation took place between three consecutive examinations two observation periods both showing increases were reported

The length of observation periods varied widely and ranged between 2 and 131 months The number of cases with propagation per 100 observation months was calculated in order to be able to compare the tendency to propagation of the obliterative changes in different groups of patients

Grouping of the observation periods and exclusions

Anticoagulant group This group consisted of observation periods with long term treatment with anticoagulants Observation periods were excluded if information about the intensity of the treatment was not available or if the treatment was started more than 3 months after the beginning of the observation period or if it was stopped more than 3 months before its termination provided the time during which no treatment was given did not exceed 10 per cent of the whole observation period

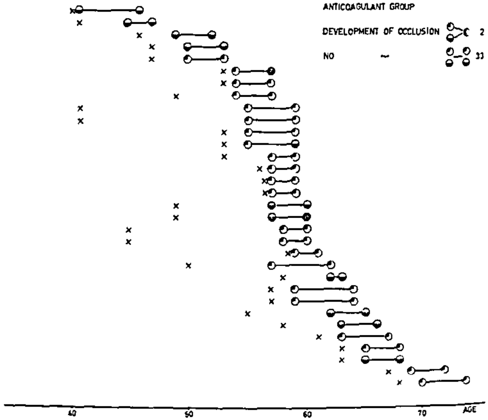


Fig 5a Tendency to development of total occlusions Onset of claudication is designated with X Partly shaded circles (cf fig 2) to the left indicate more or less accentuated arterial stenosis at the beginning of the observation period Circles at the right end of the lines denote the arteriographic state at the end of the observation period Totally shaded circles denote development of total occlusion Anticoagulant group Total occlusion developed during 2 out of 32 observation periods

Control group This group included observation periods during which the patients received no anticoagulants Observation periods during which the patients received anticoagulants for less than three months were also included provided this time did not exceed 10 per cent of the whole observation period

Observation periods in both groups that occurred after reconstructive arterial operations on one limb were excluded, while the observation periods for the non operated limb were included in the study

Results

The rapidity of propagation of obliterative arterial disease often varies in the two limbs this was recently emphasized by TAYLOR & CALO This was also verified in the present material by the findings in 41 patients who had arteriography performed on both limbs There was a total occlusion only on

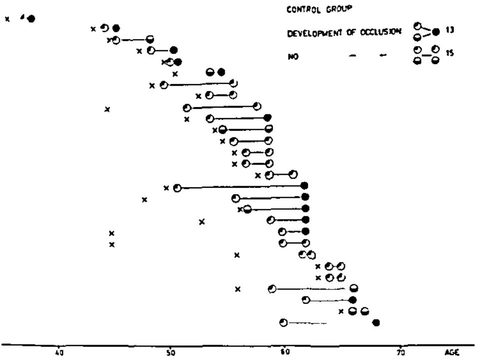


Fig 5b Control group Total occlusion developed during 13 out of 28 observation periods

one side at the first examination in 18 patients stenosing changes of different degrees were present in the other limb but no total occlusion There were still 17 patients who had an occlusion only on one side at the final examination (Table 1) It was consequently considered justifiable in all patients to give a separate account of the roentgenologic course of the disease in the two limbs

One hundred and thirteen legs were examined at least twice in the 74 patients in 12 patients 16 legs were examined three to four times The number of observation periods for the whole material was 132, out of which 77 occurred during anticoagulant treatment and 55 when anticoagulants were not given

An apparent increase in the non occluding changes of the vessel wall was not registered as a propagation of the obliterative arterial disease in the present study Such cases were registered as unchanged as long as a total occlusion did not develop or an existing total occlusion did not show appositional growth

No propagation as defined occurred during 93 observation periods (2 to 88 months in length, mean 34 8) This illustrates the benign course that obliterative arterial disease may take during certain periods

Obliterative arterial disease often runs a rather acute course when occurring in patients less than 50 years of age Only 16 observation periods were com

Table 3

Original length of total occlusions and their propagation tendency

Length in cm	Observation periods		Observation time (months)			Propagation tendency
	Total number	Propagation occurred in	Total	Mean	Range	
— 4	13	6	453	34 8	2—59	1 32
5— 9	13	5	459	35 3	16—59	1 09
10—27	34	13	1 171	34 5	4—102	1 11
28—	12	—	425	35 4	2— 88	—
Total	72	24	2 508	34 8		0 96

menced before the age of 50 in the present material but during no less than 9 of them propagation occurred, in the age group 50 to 59 years 24 of 69 observation periods revealed propagation, and in the age group 60 to 69 years only 6 out of 35 (Table 2) The tendency to propagation thus seemed to be more marked in the younger subjects in spite of the fact that the mean observation time was shorter in the youngest age group The length of the observation periods varied widely in all the groups

It was of great interest to discover how often and quickly a total occlusion developed in stenosed arteries Data on observation periods at the beginning of which no total occlusion was present were therefore collected There were 32 such periods in the anticoagulant group (Fig 5a) and 28 in the control group (Fig 5b) The average length of the observation period was 37 2 (17 to 62, total 1 188) months in the anticoagulant group and 38 4 (2 to 131, total 1077) months in the control group The average age of the patients at the beginning of the observation period was 57 2 (41 to 70) years in the anticoagulant group and 55 6 (38 to 66) years in the control group There were 9 patients with stenosing changes giving rise to collateral vessels (group II, Fig 2c) in the anticoagulant group but only 4 such patients in the control group Only 2 total occlusions had developed at the end of the observation period in the anticoagulant group but as many as 13 in the control group The number of total occlusions that developed per 100 observation months was 0 17 in the anticoagulant group but 1 18 in the control group The difference between these frequencies is statistically significant ($t = 2\ 92$, $0\ 005 > p > 0\ 001$)

The tendency of arterial thrombosis to propagate in a proximal or distal direction could be studied in patients in whom total occlusion already existed at the beginning of the observation period

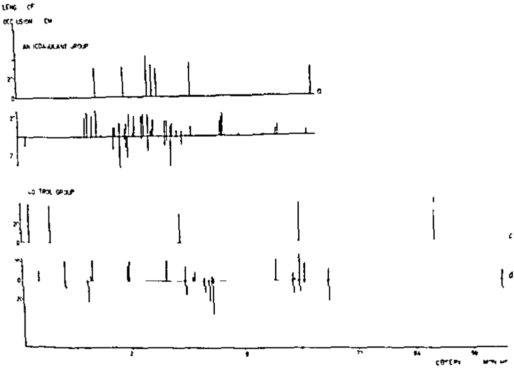


Fig 6 The length of the total occlusions at the beginning of the observation period is marked above the horizontal lines a b c d No propagation occurred in occlusions originally more than 27 cm in length (lines a and c) Appositional growth marked below the horizontal line occurred during some of the observation periods in occlusions less than 28 cm in length (lines b and d)

Short occlusions, i e 1 to 4 cm in length seemed to show a greater tendency to grow than the longer ones (Table 3) None of the occlusions that were more than 27 cm in length propagated during the observation period Such long occlusions generally extended from the origin of the deep femoral artery in a direction distal to the large arteries of the knee The collateral vessels were obviously so well developed that propagation did not occur in any of these long occlusions, regardless of whether or not the patients were receiving anticoagulant therapy (Fig 6 a and c) There were 7 such long occlusions in the anticoagulant group and 5 in the control group These observation periods were excluded in order to obtain a more correct evaluation of the propagation tendency of occlusions

There thus remained 38 observation periods in the anticoagulant group (Fig 7a) and 22 in the control group (Fig 7b) The average length of the observation period was 31 7 (2 to 62 total 1 203) months in the anticoagulant group

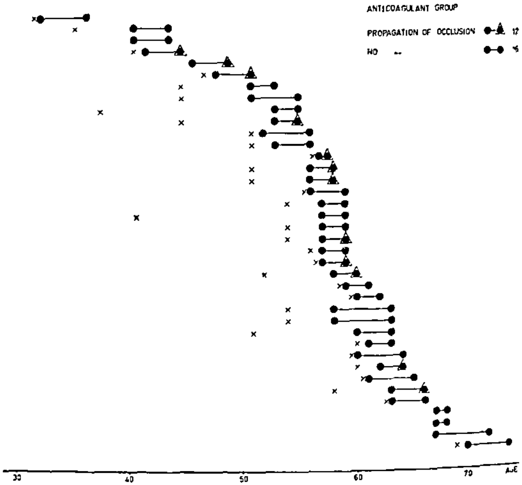


Fig 7a Tendency to appositional growth of total occlusions Totally shaded circles at the right end of the line indicate unchanged length of the occlusion at the end of the observation period Triangles around the circles mark propagation of the total occlusion during the observation period Anticoagulant group Propagation occurred during 12 out of 38 observation periods

and 40 0 (4 to 102, total 880) months in the control group The average age of the patients at the beginning of the observation period was 56 0 (33 to 70) years in the anticoagulant group and 54 8 (40 to 64) years in the control group

A propagation of the total occlusion occurred during 12 out of 38 observation periods in the anticoagulant group and during 12 out of 22 such periods in the control group The number of total occlusions that increased in length per 100 observation months was 1 0 in the anticoagulant group and 1 36 in the control group The difference is not statistically significant

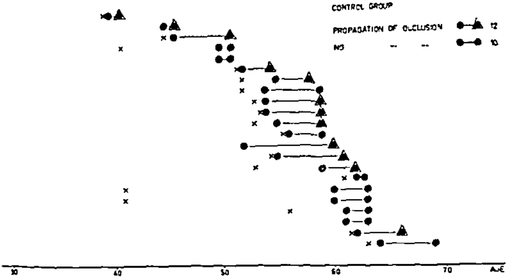


Fig 7b Control group Propagation occurred during 12 out of 22 observation periods

Discussion

The natural course of obliterative arterial disease may vary considerably in different patients An impairment in the circulation of the lower limbs may develop slowly over several years, or occur in bouts with more or less acute symptoms followed by an unchanged or even an improved clinical state, if the ability to produce collateral vessels exists

Acute impairments in the peripheral circulation correspond to the development of total occlusions in the arteries, generally a thrombotic process or to a propagation of an existent thrombosis, cutting off large collateral vessels If only small collateral vessels are cut off the thrombotic progress may be largely unnoticed by the patient Occult total occlusion of a stenosed artery may also occur if the obstruction of the blood stream occurs slowly and collateral vessels have developed these collateral vessels compensate for the loss of blood flow in the stenosed main vessel

The larger the collateral vessels at both ends of an occlusion the greater is the possibility for such an occlusion to remain unchanged for a long time It was found in the present material that when occlusions in the superficial femoral artery extended between the origin of the deep femoral artery and the large arteries of the knee there was no further propagation of the thrombosis, whether the patients were treated with anticoagulants or not

Our knowledge of the factors that may influence the course of obliterative arterial disease is still very incomplete It is impossible to predict the natural

course of the disease at a given time The actual observation period may thus occur during a more or less acute phase of the disease It would consequently be of dubious value under such circumstances to prescribe different kinds of therapy based upon a random statistical plan

As many observation periods as possible during which the patients had been under anticoagulant therapy (77 periods) or had not received such treatment (55 periods) were considered in the present material The two groups were similar in age distribution and serum cholesterol level The relative number of patients with enlargement of the heart was the same in both groups

The 4 observation periods for the diabetic patients were all in the control group but did not show any progress in the femoropopliteal area Out of the 5 observation periods in patients with Buerger s disease, 3 were in the control group and 2 in the anticoagulant group There were 14 observation periods for females in the anticoagulant group but only 5 among the controls

There were more patients with a high degree of stenosis (group II, Fig 2c) in the anticoagulant (9 patients) than in the control group (4 patients) and nevertheless the number of occlusions that developed during the observation period was significantly larger in the control group This finding makes it very probable that by anticoagulant therapy total occlusion of stenosed vessels can be delayed, at least in the femoropopliteal artery

There was also a difference between treated patients and controls with regard to the propagation of existing total occlusions This difference, however, was not statistically significant The propagation tendency of occluding thrombosis seemed to depend to a great extent on the width of the collateral vessels that allow the blood stream to by pass the occlusion

Conclusions

The course of obliterative arterial disease was studied in the femoral artery and its main branches by means of repeated arteriographies during the years 1945—1961 The technique with exposures in one plane only allowed an assessment of (1) whether total occlusions developed in stenosed arteries during the observation time, and (2) whether total occlusions propagated during the observation time

Out of 132 observation periods no propagation occurred during 93 periods (of 2 to 88 months duration, mean 34 8), thus illustrating the benign course that obliterative arterial disease may take

Short occlusions had a greater tendency to grow than long ones No occlusion that was more than 27 cm at the beginning of the observation period propagated in the present material When the occlusion had reached a large collateral vessel the tendency to further propagation seemed to decrease

Patients receiving anticoagulant therapy were less likely (statistically significant) to develop total occlusions and had a lower tendency (not significant) to propagation of total occlusions, than those not treated with anticoagulants

As there is a great variability in the natural course of obliterative arterial disease not only in different patients but also in the same patient at different periods an evaluation of the therapeutic results is difficult Further aspects of this problem will be published later by one of us (C T)

The investigation was carried out with the aid of grants from Svenska Nationalforeningen mot Hjart och Lungsjukdomar and from Nordisk Insulinfond

SUMMARY

Seventy four patients with intermittent claudication were investigated with repeated arteriographies over a mean observation period of about three years Some of the patients were treated with anticoagulants No propagation of the obliterative changes occurred during most of the observation periods. Patients treated with anticoagulants developed total occlusions less often than those who were untreated Existing total occlusions showed less tendency to grow in the anticoagulant group than in the control group

ZUSAMMENFASSUNG

Vierundsiebzig Patienten mit Claudicatio intermittens wurden mittels wiederholter Arteriographie uber eine Beobachtungszeit von ungefähr 3 Jahren kontrolliert Ein Teil der Patienten erhielt anticoagulierende Substanzen In den meisten Beobachtungsperioden erfolgte keine Ausdehnung der obliterierenden Veranderungen Patienten die anticoagulierende Medizinen erhielten entwickelten volligen Gefassverschluss seltener als die Patienten die nicht so behandelt wurden Bestehender volliger Gefassverschluss neigte weniger zur Ausbreitung in den behandelten Fallen als in den unbehandelten

RÉSUMÉ

Soixante quatorze malades atteints de claudication intermittente ont été examinés à plusieurs reprises par arteriographie au cours d une période d observation de trois ans en moyenne Certains de ces malades ont été traités par des anticoagulants Les lésions oblitérantes ne se sont pas etendues dans la majorité de ces périodes d observation Les malades traités par les anticoagulants ont évolué moins souvent vers l obstruction complete que les malades non traites Les obstructions complètes existantes ont eu moins tendance a augmenter dans le groupe traite par les anticoagulants que dans le groupe temoin

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AUS DEM INSTITUT FÜR MEDIZINISCHE OPTIK (VORSTAND PROF. H. SCHOBER) DER UNIVERSITÄT MÜNCHEN, DEUTSCHLAND

DIE ANWENDBARKEIT DER IN DER OPTIK GEBRÄUCHLICHEN KONTRASTÜBERTRAGUNGS- UND INFORMATIONSTHEORIE AUF DIE ABBILDUNG MIT RÖNTGENSTRAHLEN

von

HERBERT SCHOBER und MANFRED HOFERT

Die Bilderzeugung durch Röntgenstrahlen und die Struktur des Röntgenbildes wurde bisher üblicherweise in Anlehnung an die in der Optik gebräuchlichen Methoden als Zentralprojektion behandelt (EGGERT 1951, SPIEGLER 1954, 1957). Dabei wurde berücksichtigt, daß der Röhrenbrennfleck in Wirklichkeit keine Punktquelle darstellt, sondern eine gewisse Ausdehnung besitzt. Das vom Röhrenbrennfleck ausgehende Strahlenbündel wird in seinen äußeren Dimensionen durch eine reelle Blendenöffnung begrenzt. Infolge von Streuung und Schwächung beim Durchgang durch das Objekt entsteht im Bündel eine ungleichmäßige Verteilung der Energiedichte, das sogenannte Strahlungsrelief. Dieses wird entweder auf einem Leuchtschirm oder einer photographischen Emulsion abgebildet und damit sichtbar gemacht.

Für die Erzeugung eines guten, detailreichen Röntgenbildes sind verschiedene Faktoren maßgebend, deren Zusammenspiel nicht ohne weiteres zu übersehen ist. In erster Linie spielen die Brennfleckgröße und die Abstände zwischen Brennfleck, Objekt und Bildebene, die Streustrahlung, welche im

Bei der Redaktion am 26. Januar 1962 eingegangen

Objekt gebildet wird, und die Eigenschaften der Verstärkerfolien und der photographischen Emulsion, bzw. des Leuchtschirmes eine Rolle. Man hat zwar versucht, zwischen diesen Eigenschaften Beziehungen aufzufinden und damit Bedingungsgleichungen für die Bildgüte aufzustellen. Es ist aber nicht gelungen, zu in allen Richtungen befriedigenden Ergebnissen zu gelangen.

Da ähnliche Verhältnisse, wie sie eben geschildert wurden, auch im Bereich der optischen Abbildung bestehen, erscheint es begreiflich, daß man versucht, die dort gemachten Erfahrungen auch auf die Abbildung mit Röntgenstrahlung zu übertragen. Das betrifft vor allem die Anwendbarkeit der Informationstheorie und Kontrastübertragungstheorie.

Seit im Jahre 1948 der irische Hochfrequenzphysiker Shannon eine neuartige Methodik zur Darstellung der Nachrichtenübertragung für die Hochfrequenztechnik und Elektroakustik entwickelt hat, ist es um diese, in der Fachwelt kurz „Informationstheorie" genannten Probleme nicht mehr still geworden. In Verbindung mit ähnlichen älteren Überlegungen von Gabor, Wiener, Küpfmüller, Nyquist und anderen Autoren, ist es gelungen, eine Reihe von Fragen zu lösen, die bisher als unlösbar oder zumindest als schwer lösbar galten. Die großen Erfolge dieser Methodik hatten aber auch den Nachteil, daß man vielfach ohne genaue Kenntnis der Grundlagen und der Grenzen dieser Betrachtungsweise versucht hat, sie auf Gebiete auszudehnen, für die sie ursprünglich gar nicht geschaffen waren. Da die informationstheoretischen Überlegungen sowohl im Bereich der Optik als im Bereich der Röntgenbild-Detailerkennbarkeit zunehmend eine Rolle spielen, sei es daher gestattet, ihre Bedeutung und ihre Grenzen von der Grundlagenseite her aufzuklären.

Jede Nachrichtenquelle (Sender, Geber) besitzt nach der Informationstheorie eine bestimmte Nachrichtenträchtigkeit. Sie ist also imstande, in der Zeiteinheit eine bestimmte Anzahl von Nachrichten auszustrahlen. Vom Sender wird die Nachricht über irgendwelche Übertragungssysteme, den sog. Übertragungskanal zum Empfänger geleitet, der ebenfalls eine begrenzte Aufnahmekapazität für Nachrichten, die sog. Empfangsträchtigkeit, besitzt. Eine Begrenzung für die Zahl der Nachrichten in der Zeiteinheit gibt es aber nicht nur beim Sender und Empfänger, sondern auch beim Übertragungskanal. Dieser besitzt ebenfalls eine endliche Nachrichtenkapazität (Kanalkapazität). Eine besondere Schwierigkeit besteht aber beim Übertragungskanal noch darin, daß in ihm nicht nur Nachrichten aus dem Geber einströmen. Es entstehen in *ihm vielmehr auch Störsignale, die einen Teil seiner Nachrichtenkapazität* mit Beschlag belegen und unter Umständen, wenn sie stark genug sind, den Empfang der Nachricht im Empfänger überhaupt verhindern können. Dieser Vorgang ist beim Rundfunkempfang als sog. „Rauschen" allgemein bekannt. Je stärker das „Rauschen" ist, desto mehr wird die Wiedergabe von Nachrichten beeinträchtigt. Wegen der besonderen Bedeutung der Rauscherscheinungen hat man diesen Begriff auch in die von Shannon entwickelte Theorie aufgenommen und bezeichnet im Rahmen der Informationstheorie alle jene Störungen im

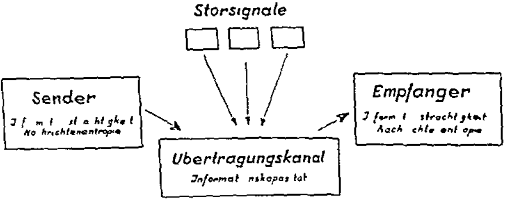


Abb 1 *Die Grundbegriffe der Informationstheorie* Der Sender kann eine bestimmte Zahl von Nachrichten weitergeben Er hat eine Informationsträchtigkeit oder Nachrichtenentropie Der Übertragungskanal zwischen dem Sender und Empfänger hat ebenfalls nur eine bestimmte Aufnahmekapazität für Nachrichten (Informationskapazität) In ihn gelangen aber nicht nur Nachrichten aus dem Sender sondern auch die Störsignale Auch der Empfänger hat nur eine begrenzte Informationsträchtigkeit (Nachrichtenentropie) Infolgedessen kann er meist nicht alle Nachrichten empfangen die der Sender aussendet Außerdem trifft man in ihm neben Nachrichten aus dem Sender Nachrichten der Störquellen (Störsignale) ein

Übertragungskanal als „Rauschen", die den Gesetzen der Statistik gehorchen (Abb 1)

Will man die eben aufgestellten Definitionen und die aus ihnen entwickelten Rechenformeln auf die Gebiete der Optik und der Röntgenbilderzeugung anwenden so ist es unerläßlich, noch einige Umstände zu beachten, die von entscheidender Bedeutung sind So spielt im Bereich der Optik und des Röntgenbildes das Zeitproblem eine ganz andere Rolle als etwa in der Hochfrequenztechnik und Elektroakustik Während es nämlich im letzteren Falle sich um die zeitliche Aufeinanderfolge von Schwingungen verschiedener Frequenz handelt müssen wir im Bereich der Optik und des Röntgenbildes nur im Ausnahmefall eine zeitliche im Regelfall aber eine *räumliche* Verteilung von Nachrichten betrachten, wie sie im Strahlungsrelief gegeben ist Die Zeitkoordinate muß hier also durch zwei Ortskoordinaten ersetzt werden Außerdem hat man es hier immer mit einer praktisch *unendlichen* Fülle von Nachrichten nämlich mit dem Strahlungsrelief zu tun, *während* in der elektrischen Nachrichtentechnik vielfach auch Einzelnachrichten betrachtet werden können z B die Folge von Stromstößen die bei der Telegraphie nach dem Morse Alphabet entstehen Weiterhin fehlt *im* Bereich der Optik und der Röntgenbilddarstellung vielfach die für die informationstheoretischen Berechnungen notwendige Voraussetzung der *linearen* Addierbarkeit von Nachrichten Wegen der nichtlinearen Gradationskurve der meisten photographischen Emulsionen bedeutet beispielsweise eine doppelte Bestrahlungsenergie nur selten eine Verdopplung der Schwärzung Endlich besteht im Bereich der Optik und Röntgenbilddarstellung eine weitere, in der Elektroakustik nicht

auftretende Schwierigkeit, nämlich das Fehlen der sog. Verschlüsselung. Unter Verschlüsselung ist zu verstehen, daß die ursprüngliche Energie durch den Übertragungskanal in einer anderen Form geleitet wird als sie vom Sender erzeugt, bzw. vom Empfänger aufgenommen wird. In der Elektroakustik hat man es beispielsweise am Ort des Mikrophons und des Lautsprechers mit mechanischer Schwingungsenergie (Schallenergie) zu tun, während sich im Übertragungskanal nur Vorgänge im Bereich der elektrischen Energie abspielen. Von einer weiteren Eigenschaft der Bildinformation, nämlich der unterschiedlichen Bewertung des einzelnen Details je nach der erhobenen Fragestellung, der sog. „spezifischen Ästhetik" soll hier nicht weiter die Rede sein, obwohl gerade diese Eigenschaft eine grundlegende Bedeutung für das ganze Bildinformationsproblem überhaupt hat.

Die oben geschilderte Sonderheit im Bereich der Übertragung optischer Bilder, nämlich die Forderung an Stelle der Zeitkoordinate zwei Raumkoordinaten einzuführen, hat zu folgender Überlegung geführt.

Man denke sich das Objekt, bzw. das Bild in ähnlicher Weise, wie man es praktisch in der Drucktechnik macht, durch zwei aufeinander senkrecht stehende Strichrastersysteme zusammengesetzt. Wählt man dabei für das einzelne Strichraster bei den Rasterstrichen nicht eine Rechteckform, d. h. läßt man nicht unmittelbar neben den weißen Zwischenräumen die scharfbegrenzten Rasterstriche stehen, sondern sorgt dafür, daß die Schwärzung im Rasterstrich nach einer Sinuskurve ansteigt und nach Erreichung des Maximums wieder abfällt, so hat man an Stelle des sonst üblichen Rechteckrasters ein Sinusraster vor sich. Diese Darstellung hat einen wesentlichen Vorteil. Genau so wie man nämlich bei den akustischen und elektrischen Schwingungen die Frequenz durch die Zahl der Sinuswellen pro Sekunde angibt, kann man auch in einem derartig gebauten Sinusraster die Zahl der Rasterstriche pro Millimeter als sog. Ortsfrequenz oder Raumfrequenz definieren und hat damit für die späteren Rechnungen die zeitliche in eine räumliche Koordinate verwandelt.

Durch jede Bildübertragung werden die Feinheiten des Objektrasters in irgendeiner Weise verändert. In der Regel fallen die feineren Einzelheiten weg oder zumindest ist bei ihnen die Schwärzung nicht so hoch wie beim Original. Das wird vor allem am Empfängerschirm oder in der photographischen Schicht schon deshalb geschehen, weil die dort vorhandene Körnigkeit die Darstellung beliebig feiner Raster überhaupt nicht gestattet. In Anlehnung an die Bezeichnungsweise der Hochfrequenzphysik spricht man in einem solchen Falle von Frequenzfilterung und nennt das Abschneiden der hohen Frequenzen, also die Begrenzung des Frequenzbandes nach oben, ein Tiefpaßfilter.

Trägt man in einem Koordinatensystem als Abszisse die Ortsfrequenz, d. h. die Zahl der Rasterstriche pro Millimeter und als Ordinate den photometrischen Kontrast zwischen dem Schwärzungsmaximum und der Stelle des Zwischenraumes zwischen zwei Rasterstrichen sowohl für das Objekt als auch das

Bild ein, so erhält man jeweils eine Kurve, die das im Objekt oder Bild vorhandene räumliche Frequenzspektrum wiedergibt. Aus dem Verhältnis der jeweiligen Ordinatenwerte von Bild und Objektfrequenzspektrum wird eine neue Kurve gewonnen, die als Kontrastübertragungsfunktion (KÜF) bezeichnet wird. Mit Hilfe der KÜF ist die Bildwiedergabe weitaus besser zu kennzeichnen als durch die bisher benutzten Methoden, nämlich die Angabe von Kontrast und Schwärzung bei einer bestimmten Bilddarstellung. Es ist daher nicht weiter verwunderlich, wenn diese Darstellungsmethode sich steigender Beliebtheit erfreut. Die KÜF besitzt aber noch einen weitern Vorteil. Es läßt sich nämlich rechnerisch zeigen, daß die Kontrastübertragungsfunktion eines kompliziert zusammengesetzten Übertragungssystems dadurch bestimmt werden kann, daß man (unter Voraussetzung der auf Seite 1181 erwähnten linearen Addierbarkeit) die KÜF der einzelnen Teilglieder berechnet und diese Teil-KÜF miteinander multipliziert. Wendet man dieses Gesetz auf eine kompliziertere Abbildungsweise im Röntgenbereich, wie etwa die Schirmbildphotographie an, so heißt das, daß die KÜF eines Schirmbildgerätes als Produkt aus der KÜF des Empfängerschirms, der Optik und der benutzten photographischen Emulsion berechnet werden kann.

Zur Durchführung der Berechnung wählt man zweckmäßig den folgenden Weg.

Die örtliche Verteilung der Energiedichte im Strahlenrelief $F(x, y)$ hinter dem Objekt (x, y sind die Ortskoordinaten in der Objektebene) läßt sich nach einem von Fourier aufgestellten Lehrsatz als zweidimensionales räumliches Frequenzspektrum $e(u, v)$ mit den Koordinaten u und v in der Frequenzebene nach folgender Formel darstellen

$$e(u, v) = \iint_{-\infty}^{+\infty} E(x, y)\, e^{(xu + yv)}\, dx\, dy \tag{1}$$

Das heißt also, wenn in einem ebenen Koordinatensystem die Energiedichte in einem beliebigen Punkt mit den Ortskoordinaten x und y durch die von x und y abhängige Größe $E(x, y)$ angegeben wird, also der Verlauf von $E(x, y)$ das Strahlungsrelief in der Objektebene ist, kann man durch ein eindeutiges Rechenverfahren auch die Verteilung der Ortsfrequenzen u und v in einem Koordinatensystem mit der Abszisse u und der Ordinaten v (Linien/mm) wiedergeben. An und für sich wäre die Integration gemäß Formel (1) über die ganze Objektebene zu erstrecken (ein räumlich in der Tiefe ausgedehntes Objekt wird dabei stets auf eine gedachte Objektebene größter Schärfe projiziert). In der Praxis ist das aber deshalb nicht notwendig, weil das Strahlenrelief außerhalb der Gesichtsfeldblende, also außerhalb ganz bestimmter Grenzwerte von x und y verschwindet.

In der Bildebene befindet sich nunmehr gemäß den auf S. 1180 gemachten Ausführungen ein linearer Bildempfänger, mit dessen Hilfe das Strahlungsrelief sichtbar gemacht wird. Linear bedeutet hier, daß die Lichterregung auf dem Bildempfänger streng proportional der auffallenden Dosis sein soll. Das gilt zwar exakt für alle Fluoreszenzschirme, für die photographische Emulsion jedoch nur innerhalb gewisser Grenzen.

Aus Erfahrung weiß man, daß durch die körnige Struktur des Empfängerschirms bzw. der Verstärkerfolien und der photographischen Emulsion eine

Kontrastherabsetzung gegenüber dem „Luftbild", d h dem idealisierten Bild auf einem kornlosen Empfänger stattfinden muß Als Beweis kann die Kontrastherabsetzung beim Übergang von einer folienlosen Aufnahme zur Folienaufnahme dienen Durch diese Kontrastverminderung gehen eine Reihe von Details verloren Der Bildempfänger laßt sich also im Sinne der Kontrastübertragungstheorie als ein Filter für die Ortsfrequenzen auffassen und zwar stellt er analog zu den elektrischen Filtern in der Rundfunkübertragung ein sog Tiefpaßfilter dar

Bei der rechnerischen Darstellung bedeutet das daß die Energiedichte $I\ (x\ y)$ durch eine Funktion $I\ (x\ y)$ korrigiert („gefaltet") werden muß Diese Funktion $I\ (x\ y)$ entspricht der Impulsreaktionsfunktion der elektrischen Nachrichtentechnik und beschreibt das Verhalten des Bildempfängers bei der Abbildung eines sehr kleinen Objektpunktes

Bedeutet $B\ (x\ y)$ die Leuchtdichte des Fluoreszenzschirms bei der Durchleuchtung so ergibt sich unter Annahme der Vergrößerung 1 (der Leuchtschirm soll also am Ort des Strahlungsreliefs gedacht werden) durch diese Rechnung die folgende Formel

$$B(x\,y)=\iint_{\infty}^{+\infty} E(x\ y\,y)K(x-x\ \ y-y\ )dx\,dy \qquad (2)$$

Man kann wieder über Ausdehnung des Strahlungsreliefs integrieren da außerhalb der Blende alle Werte von $E\ (x\ \ y\ )\ 0$ werden

Rechnerisch eleganter ist es allerdings die Berechnung mit Hilfe der von Fourier eingeführten Integrationsmethode im Frequenzraum durchzuführen denn die ganze Faltungsoperation wird hier zu der Multiplikation

$$b(u\,v) = l\,(u\,v)\ e(u\,v) \qquad (3)$$

In dieser Formel bedeutet $k\ (u\ v)$ die Fouriertransformation der Zerstreuungsfigur Sie wird heute allgemein Kontrastübertragungsfunktion genannt und durch folgende Gleichung dargestellt

$$k(u\,v) = \iint_{\infty}^{+\infty} I\ (x\ y)e^{2\pi i(\ \ +\ \ y)}dx\,dy \qquad (4)$$

Die Kontrastübertragungsfunktion charakterisiert die Übertragungseigenschaften für Ortsfrequenzen durch den Leuchtschirm

Die Übertragungstheorie, wie sie eben dargestellt wurde gilt wie bereits mehrfach betont wurde, auch im Röntgenbereich nur für lineare Abbildungsprozesse, sie ist also ohne zusätzliche Einschränkungen für die Röntgenphotographie nicht anwendbar Soweit es sich aber um lineare Vorgänge handelt was bei der Röntgendurchleuchtung und beim Röntgenbildwandler, sowie beim Röntgenfernsehen (soweit nicht im elektrischen Teil Kontrastverzerrungen eintreten) immer der Fall ist, entstehen gegenüber der Optik durch die Umwandlung der Röntgenstrahlen in sichtbares Licht keine weiteren Schwierigkeiten Aus diesem Grunde kann man auch die in der optischen Übertragungstheorie gebräuchlichen Begriffe ohne weiteres auf den Röntgenbereich übertragen Es ist daher auch im Röntgenbereich zweckmäßig, an Stelle von „Strahlungsdichte im Objekt von „Objektleuchtdichte zu sprechen, und

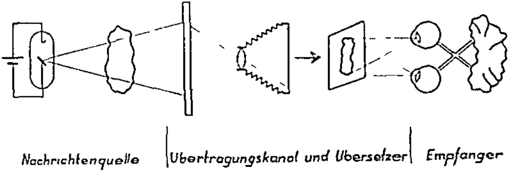


Abb. 2. *Beispiel einer komplizierteren Nachrichtenübertragung in der Radiologie (Schirmbild-Photographie).* Als Sender dient die Röntgenröhre und das durchstrahlte Objekt. Der Übertragungskanal besteht aus dem Bildschirm, der Schirmbildoptik und dem Empfängerschirm des Schirmbildgerätes. Der Kontrastübertragungsfaktor des Schirmbildgerätes setzt sich multiplikativ aus dem Kontrastübertragungsfaktor des Bildschirms, der Schirmbildoptik und des Empfängerschirms im Schirmbildgerät zusammen. Empfänger ist das menschliche Auge, oder genauer gesagt, der menschliche Gesichtssinn, der wieder aus dem abbildenden System des Auges, der Netzhaut, der Sehleitung und der Hirnrinde besteht. Auch hier kann man Kontrastübertragungsfunktionen für die einzelnen Teilsysteme aufstellen.

darunter das Strahlungsrelief hinter dem durchstrahlten Objekt in der Ebene des Bildauffängers zu verstehen. Im Röntgenbereich vereinfachen sich die für die Optik geltenden Verhältnisse sogar noch insofern, als die in der Lichtoptik, beispielsweise in der Mikroskopie bestehenden Schwierigkeiten zur Unterscheidung zwischen kohärenten und inkohärenten Strahlern wegfallen. Allerdings ist auch im Röntgenbereich genauso wie in der Optik die Erfüllung der sog. Isoplanasiebedingung notwendig. Sie bedeutet, daß die Kontrastübertragungsfunktion und daher auch die Abbildungseigenschaften sich über die gesamte Bildebene nicht verändern. Das ist in der Regel der Fall, wenn man nicht allzu große Bildbereiche untersucht.

Der besondere Vorteil in der Kontrastübertragungstheorie besteht, wie ebenfalls bereits angedeutet wurde, darin, daß sich in voller Analogie zur elektrischen Nachrichtentechnik die Kontrastübertragungsfunktionen der einzelnen Abbildungselemente miteinander multiplizieren lassen, wenn die Abbildung aus mehreren Stufen hintereinander besteht (vgl. Abb. 2). Man kann also etwa die Fokusunschärfe durch eine Kontrastübertragungsfunktion beschreiben, in dem man die Abbildung eines praktisch unendlichen kleinen Brennflecks mit den wirklichen Verhältnissen im Strahlungsrelief bei Verwendung eines endlich ausgedehnten Brennflecks vergleicht. Ebenso kann man für die Gesamtabbildung die Kontrastübertragungsfunktion des Brennflecks mit jener des Empfängerschirms (bei Berücksichtigung der Vergrößerungsverhältnisse) und weiter mit jener des Schirmbildobjektivs oder der Fernsehröhre usw. multiplizieren.

Die Kontrastübertragungsfunktion eines Leuchtschirms kann grundsätzlich auf folgende Weise bestimmt werden:

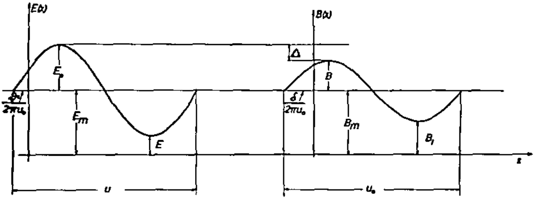


Abb 3 *Graphische Darstellung der für die Bestimmung der Kontrastübertragungsfunktion wichtigen Grössen* Die linke Figur stellt die Strahldichteverteilung $E(x)$ des Ordinatenwerts in Abhängigkeit vom Ort des Objektes x (Abszisse) dar

Die rechte Seite gibt die am jeweiligen Orte x herrschende Bildleuchtdichte $B(x)$ wieder Entsprechend bedeuten E_0 und E_1 die Strahldichte im Maximum und Minimum des Objektrasters Sie werden durch die Abbildung in die maximale Bildleuchtdichte B und die minimale Bildleuchtdichte B_1 verwandelt wobei gleichzeitig eine Einebnung der Kontraste stattfindet E_m und B_m bedeuten die mittlere Strahldichte im Objektraster bzw mittlere Leuchtdichte im Bildraster

Die Kontrastabnahme im Maximum ist durch den Betrag Δ gekennzeichnet n bedeutet die Breite eines Rasterelementes (Ortsfrequenz) die Winkel θ und δ kennzeichnen die sog Phasenlage d h den Abstand des Rasterbeginns vom Nullpunkt des Koordinatensystems

1 Man bestimmt $A\ (x\ y)$ d h die Verhältnisse bei der Wiedergabe eines Punktbildes und bildet rechnerisch die Fourier transformierte $k\ (u\ v)$ dieser Größe

2 Mit Hilfe eindimensionaler Sinus oder Rechteckstrichraster mißt man direkt die Größe $k\ (u\ t)$ wobei man in verschiedenen Richtungen die Kontrastabnahme des Strahlungsreliefs in Abhängigkeit von der Linienzahl des Rasters (Ortsfrequenz) aufträgt Benutzt man dazu Sinustest so erhält man für jede Ortsfrequenz u sofort den zugehörigen Übertragungsfaktor $k\ (u)$ dessen Betrag — für die Frequenz Null willkürlich auf eins normiert — in einem rechtwinkligen Koordinatensystem als Ordinate über den jeweiligen Abszissenwert von u aufgetragen wird (HENDEBERG 1960)

An und für sich tritt bei der Kontrastübertragung auch eine Ortsverlegung des Rasters („räumliche Phasenverschiebung") auf, die aber für das hier betrachtete Problem bedeutungslos ist und üblicherweise bei der graphischen Darstellung auch nicht berücksichtigt wird

Zur Berechnung des Kontrastübertragungsfaktors für Sinusgitterteste geht man folgendermaßen vor (Abb 3)

Die Strahldichte des Objektrasters an der Stelle x ist

$$E(x) = E_0 \sin(2\pi u + \theta) + E_m \tag{5}$$

wenn u die jeweilige Ortsfrequenz (Linien/mm) und die sogenannte Phasenlage des Gitters (Verschiebung des Gitters gegenüber dem Nullpunkt des Koordinatensystems) ist Die später definierte Konstante E_m wird lediglich dazugefügt damit $E\ (x)$ keine negativen Werte annehmen kann

Für das Bild läßt sich eine analoge Gleichung aufstellen Die Bildintensität $B\ (x)$ an der Stelle x ist dann entsprechend gegeben durch

$$B(x) = B_0 \sin(2\pi u\, x + \delta) + B_m \tag{6}$$

Die Größen E und B_s in den beiden Formeln (5) und (6) bedeuten die jeweiligen Strahldichten in Objekt und Bild für die Grundfrequenz u_s. Durch die Abbildung hat also die Intensität d. h. die mittlere Energiedichte um den Betrag $\Delta = L - B$ abgenommen. Außerdem ist das Rastersystem im Bild um die Strecke

$$\frac{1}{2\pi u}(\delta - \theta)$$

verschoben worden, was aber nach dem eben über die sogenannten „räumlichen Phasenbeziehungen" Gesagten für die hier gestellte Aufgabe ohne Bedeutung ist.

Für das jeweils betrachtete Raster erhält man nach diesen Berechnungen den Übertragungsfaktor $k(u) = B/E$.

Man kann aber auch anders vorgehen und anstelle der Intensitäten den Objekt- und Bildkontrast miteinander vergleichen. Nach der in der Optik und Kontrastübertragungstheorie üblichen Formulierung erhält man aus den Leuchtdichten B_{max} für die hellste und B_{min} für die jeweils dunkelste Stelle eines Rasters die Formel

$$C_B = \frac{B_{max} - B_{min}}{B_{max} + B_{min}} \tag{7}$$

Im Falle des Bildrasters wird also

$$C_B = \frac{B_m + B - B_1}{B_m + B + B_1} = \frac{B_s}{B_m} \tag{8}$$

und im Falle des Objekts entsprechend

$$C_E = \frac{E}{E_m} \tag{9}$$

Setzt man voraus, daß bei der Abbildung das mittlere Leuchtdichteniveau erhalten bleibt, dann ist $E_m = B_m$ und damit $k(u_s) = C_E/C_B$. Aus diesem Grunde hat die Größe $k(u)$ mit Recht den Namen „Kontrastübertragungsfaktor" erhalten.

Die Ausdehnung dieser Betrachtungen auf die photographische Abbildung und die Entwicklung einer praktischen Meßmethodik soll in einer weiteren Arbeit von HOFERT dargestellt werden.

Die Verfasser haben der Deutschen Forschungsgemeinschaft und dem Bayerischen Staatsministerium für Wirtschaft für die Verfügungstellung von Mitteln zur Durchführung dieser Untersuchungen zu danken.

ZUSAMMENFASSUNG

Der „Kontrastübertragungsfaktor" scheint für die Beurteilung der Röntgenbildqualität einen besseren Indikator abzugeben als die alten Methoden, bei denen der Kontrast und die Bildschärfe beurteilt wurden. Ein weiterer Vorteil ist, dass der Kontrastübertragungsfaktor von komplizierten Kontrastsystemen multiplikativ aus deren Komponenten errechnet werden kann. Gewisse Einschränkungen der Anwendung dieser Methode werden besprochen.

SUMMARY

The contrast transfer factor would appear to be a better indication of roentgen image quality than that obtained by the older methods of judging contrast and sharpness. It has the further advantage of permitting the assessment of complicated contrast systems by multiplication of the contrast transfer factors for the component systems. Certain limitations in the application are discussed.

RÉSUMÉ

Le « facteur de rendement de contraste » paraıt donner une meilleure indication de la qualité de l image radiographique que les anciennes méthodes d appréciation du contraste et de la finesse Il a de plus l avantage de permettre de juger des systemes de contraste compliqués en multipliant les facteurs de rendement de contraste des systemes composants Les auteurs examinent certaines limites a l application de ce facteur

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